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The American Society for Engineering Education

Forthcoming Texts

ELECTRICAL ELEMENTS of POWER TRANSMISSION LINES

by Herbert B. Dwight
Massachusetts Institute of Technology

Here is an up-to-date presentation of the main elementary propositions and calculations used by power engineers for heavy electrical lines transmitting electric power at high voltage. This treatment of the subject includes load studies, symmetrical components for short circuits, cost of resistance loss, temperature rise of conductors, and numerous problems which provide practice in working practical engineering computations. The general aspects of power transmission lines and their computation of reactance and capacitance are presented in the later chapters.

Ready in October

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by Glenn Koehler
University of Wisconsin

This new text presents the basic principles of some of the circuits and networks students will encounter in more advanced courses in electrical engineering. The book takes up some applications of circuits and networks in the general field of electrical engineering and treats coupled circuits, attenuators and equalizers, transformers and reactors, and filter circuits. The material is organized so that each chapter depends on the preceding one for complete understanding, with the exception of the chapter on transformers.

Ready in November

The Macmillan Company
60 FIFTH AVENUE, NEW YORK 11, N.Y.

International

Introduction to Electric Power Systems

JOSEPH G. TARBOUX, Professor of Electrical Engineering, University of Michigan

Covers the theory and operation of power-transmission systems under balanced steady-state conditions, and system characteristics under unbalanced or faulty operation. Treatment is confined mainly to a thorough analysis of the theoretical phases of the subject matter. For senior-level courses. *Revised edition (1949), 395 pages. $5.00.*

Theory and Application of Electrical Engineering

E. W. SCHILLING, Dean of the School of Engineering, Montana State College

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Lines, Networks, and Filters

WILLIAM M. BREAZEALE, Oak Ridge National Laboratory, and LAWRENCE R. QUARLES, Professor of Electrical Engineering, University of Virginia

Intended to strike a balance between theory and practice. Suitable for third- and fourth-year engineering or physics students after a semester or quarter course in alternating-current circuits. Utilizes rationalized MKS units throughout. *First edition (1951), 395 pages. $5.00.*

Electrical Engineering

EMERSON E. KIMBERLY, Professor of Electrical Engineering, Ohio State University

Written especially for those not majoring in electrical engineering, this book will also give those electrical engineering students who are majoring in communications a working knowledge of power machinery they are likely to need. *Third edition (1951), 394 pages. $5.50.*

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ANNUAL MEETING—PENNSYLVANIA STATE UNIVERSITY
State College, Pa. June 20–24, 1955

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Ready in the fall

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SECOND EDITION

by J. Marin & J. A. Sauer
Both at Pennsylvania State University

A revision of Marin's *Strength of Materials*, this text provides students of engineering with an introduction to mechanics of materials. With essentially the same organization, the text is completely revised to bring it up to date, including new chapters on experimental stress analysis and temperature and creep properties of materials. There is also new material on basic aspects of design, stress distribution and stress concentrations, stress on an oblique plane, vibration of beams, impact properties of materials, and fatigue.

Ready in September

Just Published

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by E. G. Paré, F. Hrachovsky, both at Illinois Institute of Technology, *& E. Tozer,* Northeastern University

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1954 40pp. $3.60

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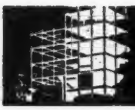

SERVOMECHANISM PRACTICE

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Explains in detail the practical aspects of servomechanisms, describes the many ways in which the essential functions of servomechanisms components can be accomplished, discusses the problems associated with the operation of servos and their components, and outlines practical design and manufacturing techniques to obtain optimum performance.

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By ABRAHAM COBLENZ and HARRY L. OWENS, Signal Corps Engineering Laboratories. In press

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CONTROL SYSTEM DYNAMICS

By WALTER R. EVANS, Group Leader, Systems Group, Autocontrol Section, Electromechanical Engineering Department, North American Aviation, Inc., Downer, California. In press

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By WALTER W. SOROKA, University of California at Berkeley. 406 pages. $7.50

An up-to-date, well-organized treatment of the more important and useful methods of analog computation and simulation, with particular reference to engineering and scientific applications. The author carefully develops the theoretical basis for each approach, providing the reader with the tools necessary for applying these methods to actual problems.

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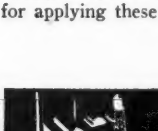

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ELEMENTS OF POWER SYSTEM ANALYSIS

By WILLIAM D. STEVENSON, JR., North Carolina State College. *McGraw-Hill Electrical and Electronic Engineering Series.* In press

Covers, in an authoritative manner, selected topics in power system analysis—parameters of power lines, transmission line calculations in the steady state, fault calculations, and power system stability particularly under transient conditions. The text takes advantage of the latest literature for treatment of the topics considered, and describes the practical methods now in current use.

ELEMENTS OF SERVOMECHANISM THEORY

By GEORGE J. THALER, U. S. Naval Postgraduate School, Monterey, California. *McGraw-Hill Electrical and Electronic Engineering Series.* In press

This new book covers the elements of feedback theory and the normal methods of applying them. Single loop systems are treated fully; and sufficient material on multiloop systems is included to introduce the problems involved and the basic approach to solutions. Higher mathematics has not been used, and in order to provide adequate practice in modern techniques, the polar and logarithmic approaches are handled simultaneously.

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This graduate-level development demonstrates the manner in which the feedback and network theory of the electrical engineer combines with the complex function theory and Laplace transform theory of the mathematician to form the theoretical basis for the relatively new field of systems of control engineering. Here is a complete, up-to-date presentation of the methods useful in the design of feedback systems.

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This elementary text in thermodynamics covers material suitable for mechanical engineering students or as a service course for aeronautical, civil, or electrical engineering students.

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352 pages · 5⅝" x 8⅜" · Publication October 1954

THE SLIDE RULE

By J. N. ARNOLD, *Purdue University*

Comprehensiveness keynotes this new text; it is not limited to one particular scale arrangement as found in the usual manual published by slide rule manufacturers. Instead, it gives instructions for identifying the appropriate scales on several different popular makes of slide rules, and for operating them. All examples and illustrations are described in specific terms.

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Now has coordinated problem material on the elementary, intermediate, and advanced levels

KINEMATICS OF MACHINES

By R. T. HINKLE, *Michigan State College*

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By reducing material on topics of lesser importance, such as flat belts, rope drives, and cycloidal gears, Professor Hinkle has been able to include some unusual topics, and cover some topics more fully than they are covered in most other texts. Unusual topics include: A description of the nature of hypoid gears, a theoretically correct method for obtaining rolling curves, and a presentation of gear interchangeability based on symmetry of the basic rack.

240 pages · 6" x 9" · Published 1953

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WILEY BOOKS

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By William H. Severns, *University of Illinois*, H. E. Degler, *The Marley Co., and* John C. Miles, *University of Illinois*. Enlargement, new material, new diagrams, and new problems mark the fifth edition of this widely useful book. Emphasis has been placed on steady-flow analysis, and new chapters include material on gas turbines and mechanical refrigeration. *1954. 502 pages. $6.50.*

MATERIALS of CONSTRUCTION

By M. O. Withey *and* G. W. Washa, *both of the University of Wisconsin.* This book provides the latest data concerning the sources, manufacture, and fabrication of the principal materials of construction. Covers the more important mechanical and physical properties of materials, and the influence of various factors on these properties. Surveys the most useful testing apparatus. *1954. 887 pages. $9.00.*

DIELECTRICS and WAVES

By Arthur R. von Hippel, *The Massachusetts Institute of Technology.* This book embraces any non-metal—or even boundary-case metal—where its interaction with electric, magnetic, or electromagnetic fields is under consideration. Shows how dielectric analysis has gone far enough to permit the beginnings of dielectric synthesis. Offers the electrical engineer new tools with which to work. *1954. 284 pages. $16.00.*

DIELECTRIC MATERIALS and APPLICATIONS

Edited by Arthur R. von Hippel. Twenty-two contributors provide fundamental information on four vital aspects of insulation in modern electrical engineering. They show: how the phenomena of polarization, magnetization and conduction can be described macroscopically; how these phenomena can be measured; what the properties of present-day materials are; and how dielectrics are used as devices. Co-published with The Technology Press, M.I.T. *1954. 438 pages. $17.50.*

FARM BUILDINGS, Fourth Edition

By Deane G. Carter, *University of Illinois.* Deals with buildings as a phase of farm improvement. The discussion of production-management is new in this edition, as is much material on building objectives, planning resources, and basic ideas of units, patterns, and primary controls. *1954. 291 pages. $5.50.*

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STRENGTH and RESISTANCE of METALS

By John M. Lessells, *Consulting Engineer.* The author emphasizes *behavior* of metals under stress. Treats such subjects as static tension or compression; creep at elevated temperature; cyclically varying stresses; suddenly applied loads, etc. Gives engineering significance to results of theoretical mechanics. *1954. 450 pages. $10.00.*

HIGHWAY ENGINEERING

By the late Laurence Hewes, *and* Clarkson H. Oglesby, *Stanford University.* Concentrating on fundamentals, the authors describe the principles which underlie highway engineering design. Treatment includes highway economy and finance, drainage, rights of way, and traffic engineering. *1954. 628 pages. $8.00.*

TELEVISION, Second Edition

The Electronics of Image Transmission in Color and Monochrome

By V. K. Zworykin *and* G. A. Morton, *both of the RCA Laboratories Division, RCA.* Presents a detailed account of the entire television system with special emphasis on the two fundamental elements—the camera tube and the kinescope. Every chapter in this edition has been rewritten and brought up to date, and the book contains the first full discussion of *color television. 1954. 1037 pages. $17.50.*

DATA BOOK for CIVIL ENGINEERS

Volume III: *Field Practice,* Second Edition

By Elwyn E. Seelye, *Seelye Stevenson Value and Knecht, Consulting Engineers.* Completely revised, this volume furnishes the engineer or inspector with sufficient data to enable him to perform his duties even if cut off from other references. Pocket-size, it covers almost every branch of civil engineering. *1954. 394 pages. $7.50.*

Volume I: *Design,* Second Edition. *1951. 521 pages. $12.00.*

Volume II: *Specifications and Costs,* Second Edition. *1951. 506 pages. $14.00.*

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Second Edition

By Paul J. Kiefer *and* Gilbert Ford Kinney, *both of the U. S. Naval Postgraduate School, and* Milton C. Stuart, *Lehigh University.* Entirely rewritten, this volume provides new material on the analyses of modern high-velocity devices, and also unifies mechanical, chemical, and fluid-mechanics applications in a manner that is up to date and directly applicable to current engineering practice. *1954. 540 pages. $7.75.*

ENGINEERING ANALYSIS
An Introduction to Professional Method

By D. W. Ver Planck *and* B. R. Teare, Jr., *both of the Carnegie Institute of Technology.* Details the processes by which real problems of engineering can be reduced to mathematical terms. Includes a point-by-point analysis of the professional engineer's thought process. *1954. 344 pages. $6.00.*

WELDING for ENGINEERS

By Harry Udin, *M.I.T.,* Edward R. Funk, *Goodyear Aircraft Corporation, and* John Wulff, *M.I.T.* Serves as a bridge between the sciences and a given engineering discipline—welding. Provides a combination of fundamentals which furnish a solid base from which the reader can solve a variety of welding problems. *1954. 430 pages. $?.*

WATER SUPPLY and WASTE-WATER DISPOSAL

By Gordon M. Fair, *Harvard University, and* John C. Geyer, *The Johns Hopkins University.* Sets forth for the first time many of the important methods by which the design of water and waste-water works may be reduced to an orderly process of calculation. The authors have classified their material according to principles of unit operations. *1954. 973 pages. $15.00.*

TRANSIENT ANALYSIS of ALTERNATING CURRENT MACHINERY

By Waldo V. Lyon, *Massachusetts Institute of Technology.* The product of more than twelve years of research, this book offers the first systematic application of Fortescue's method of symmetrical components to the solution of transient conditions in A-C machinery. Co-published with The Technology Press, M.I.T. *1954. 310 pages. $7.00.*

MODEL ANALYSIS of STRUCTURES

By T. M. Charlton, *Merz and McLellan, England. 1954. 142 pages. $?.*

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Biographical Sketch of Nathan W. Dougherty

President of ASEE

The new president of ASEE has had a long career in engineering education and added to it he has had many summer excursions into the practice of the engineering profession. No early weather vane pointed in the direction of engineering, though early work with a hoe and hayfork got him nearer engineering by eliminating another major profession.

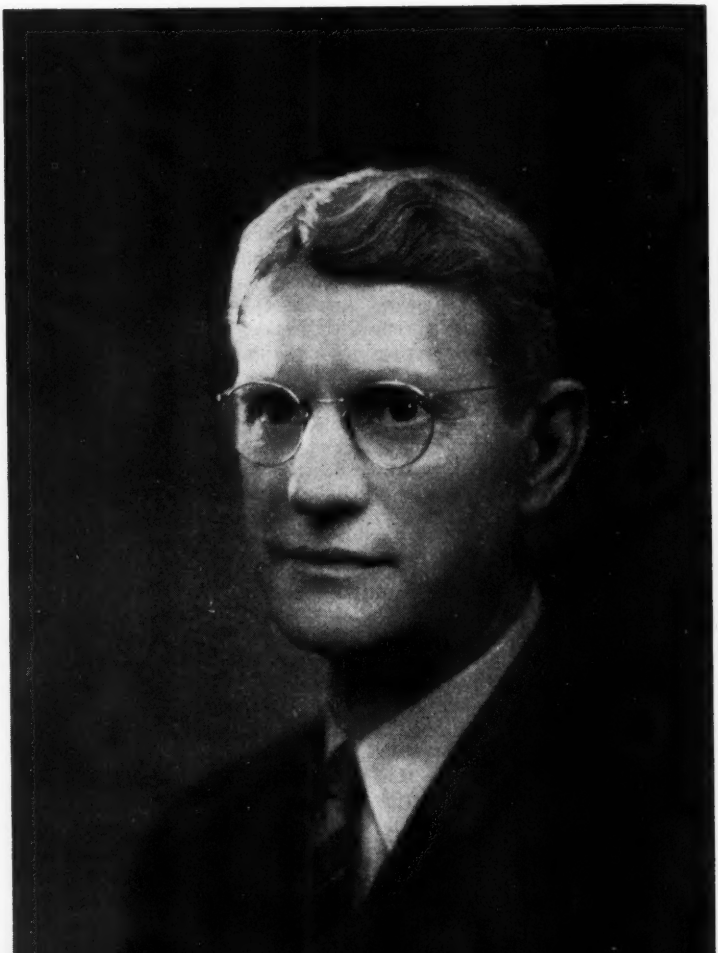
While still in the secondary school he was interested in highway and railway construction, and he had been especially intrigued by the construction of the Gay Street bridge over the Tennessee River at Knoxville. He remembers to this day the large derrick swinging steel into place on a cantilever reaching far out over the river. In later years he was pleased to meet the designer of the bridge and to read his book on artistic bridges which gave a picture of the Tennessee River bridge at Knoxville.

After graduation from secondary school he began his plans for entering the University. One day he drove to Knoxville for an interview and to get needed information about entrance requirements. It appeared that there was doubt about the standing of his school, and one of the professors asked if he had studied geometry. He replied that he had studied Wentworth's plane geometry. Then he was asked if he had worked any of the originals, and when he answered that he had worked all of them, his admission was assured. He entered the University of Tennessee in 1905 to study civil engineering and graduated in 1909.

After a half year spent in high school teaching and a half year in railroad construction he entered Cornell University as a student and instructor. For four years this combination continued, then after receiving two degrees, he cast his lot in the teaching field as assistant professor of civil engineering at George Washington University. To this time it was a toss-up between entering engineering practice or the field of teaching, but from 1914 the die was cast for teaching, and in spite of many opportunities to leave the field he has held steadfastly to the classroom, the laboratory and the chair of the engineering college administrator. After two years in Washington, he moved back to his alma mater where he has served for thirty-eight years, first as department head in civil engineering, and since 1940 as dean of the College of Engineering.

Brief excursions into engineering practice comprise such jobs as rodman and instrument man on railway construction during 1910, summer employment as junior engineer with the Southern Railway from 1917 to 1920, special assistant with the Bureau of Public Roads, now Public Roads Administration, for the summers of 1921 and 1922, special assistant with the Tennessee State Highway Department during the summers of 1923 to 1933. During 1934 and 1935 he was State Representative of the Coast and Geodetic Survey, operating the local controls survey for the state. During the period he employed nearly four hundred engineers, organized them into field parties and supervised their work throughout the state. During the summer of 1936 he was charged with the organization of the Highway Planning Survey of the Tennessee State Highway Department.

Though not an active research worker



NATHAN W. DOUGHERTY, PRESIDENT

himself, he has been interested in organizing and furthering research since his college days. As was the custom in 1909 his classmates selected him as commencement speaker for engineering. His topic was the "Need of an Engineering Experiment Station in Tennessee." When the station was organized in 1921 he wrote bulletin number 1, and the next year he wrote bulletin number 4.

These were the years of beginning activity in highway research on a national scale. He was one of those who organized the Highway Research Board, of the National Research Council. For a number of years he was a member of the committee on highway traffic, and contributed papers at the annual meetings. Before the SPEE combined the research, teaching and administrative divisions into the ASEE he, and others, had organized a research division of the Southeastern Section of which he was first chairman. He has served one term on the executive committee of the research division of ASEE.

In the land-grant college association he has also been active. He has served as chairman of the research committee for engineering; he has been secretary, vice chairman and chairman of the engineering division and is now completing his three-year term on the Executive Committee of the Land Grant Colleges and Universities Association.

His society activities have been extensive. In 1921 he was appointed to the first state board for architectural and engineering registration in his state and he has served continuously since that time. Since 1927 he has been chairman of the Tennessee Board. In 1934 he was President of the National Council of State Boards of Engineering Examiners, and during the years he has been active on many of the Council's committees, and has twice served as director for the southern zone.

He is now a life member of ASCE. He has served as a member of the education committee of that society and a member of the Board of direction from 1943 to 1946, and while on the Board he served as chairman of the committee on publications. He has contributed several articles and discussions to Civil Engineering and to the Transactions.

During the first decade of the life of ECPD he served as a member of Council for two terms, representing the NCSBEE, 1938 to 1944. While on the Council he served a term as member of the executive committee. From 1942 to 1948 he was a member of the committee on professional recognition and chairman from 1945 to 1947. From 1951 to 1953 he was a member of the Education Committee, charged with inspections in Region V, and since 1953 he has been chairman of the Committee on Student Development.

His most recent activity in a professional society has been with the National Society of Professional Engineers. He has served as chairman of the committee on education, as a member of the board of directors, 1950–1952, and as vice president 1952 to 1954. During the period he has contributed articles to American Engineer.

He has had a long contact with ASEE. He first became a member of the society in 1913, continued active for a number of years, then allowed the press of outside work to divert him from activity, then he became active again in the mid-thirties. He was a member of Council 1941–1944 and vice president 1944–1945. He has served on the Committee to Study Engineering Education After the War, the Committee on Improvement of Engineering Teaching and the present Committee on the Evaluation of Engineering Education. He has contributed many articles to the JOURNAL OF ENGINEERING EDUCATION. Locally he was acting chairman of the Southeastern section in 1941, chairman of three Fontana Conferences and published the proceedings of these conferences.

When he was a boy he heard that all work and no play makes Jack a dull boy. He has had his part in play. During his college career at Tennessee he played football, basketball and track and became captain of all three teams. On his re-

turn to the University of Tennessee his athletic career began all over again. He became chairman of the Athletic Board in 1917 and has continued this responsibility during all the years. He has been active in athletic affairs outside the University, having been the first secretary-treasurer of the Southern Conference, a member of its executive committee and its president in 1929. He was vice president of the NCAA twice and a member of the executive committee during the stormy years of the Sanity Code. At the present time he is secretary-treasurer of the Southeastern Conference. For an interim year he acted as commissioner for this conference.

In spite of his play and attention to many outside activities he is a member of Phi Kappa Phi, Tau Beta Pi and Sigma Xi from his college days and an honorary member of Pi Tau Sigma, Chi Epsilon and Iota Lambda Sigma.

He takes great pride in his family. In 1913 he married Agnes Monteith, a graduate, B.A. and M.A. Cornell University. Their five children, two boys and three girls, are all graduates of the University of Tennessee. The two boys Nathan and Edward graduated in civil engineering and and the three girls, Marie, Mildred and Agnes, two of whom graduated in liberal arts and one in business administration, married engineers. They now have thirteen grandchildren and hope that by the end of the present year they will have fourteen.

Sections and Branches

The **Michigan Section** held its annual meeting at the University of Michigan on May 8, 1954. Approximately 200 persons attended this meeting.

F. L. Schwartz presided at the General Session. W. P. Godfrey, representative to the Council from the Michigan Section, reported on the activities of the Committee on Society Functions and the Ethical Standards Committee. A. B. Bronwell reported briefly on the activities of the national group in relation to the Evaluation of Engineering Education, the Study of Graduate Programs, Humanistic-Social Project, Program for Summer Institutes, Programs of Summer Schools by Divisional Groups, Financing of graduate programs by industrial groups in conjunction with ASEE, Study of methods to get young engineering teachers more interested in activities of ASEE, General comments on the Annual Meeting in Urbana, Importance of Society activities at the Institutional level.

A panel discussion on "Evaluation of Engineering Education" followed. The panel members and their topics were: Dean G. G. Brown, "Curriculum," V. P. W. E. Stirton, "Selection and Guidance of Students," Dean Elect J. D. Ryder, "Development of an Engineering Faculty."

The following officers were elected for the year 1954–55: Chairman, C. C. Sigerfoos; Vice Chairman, G. H. Howell; Secy.-Treas., C. Fanning; Rep. on Council, R. H. Schoonover.

Educating Professionals

Editorial by N. W. DOUGHERTY, *President of ASEE*

Having been a participant in engineering education for nearly fifty years, and having observed the impact of engineering on industry for a longer period, I am thrilled at the prospect for the next generation. My generation has constructed the plants and equipped them for assembly line production; the new generation will refine them, develop new sources of power and make new products which are now hidden in the recesses of the imagination.

For the last two years we have been engaged in an evaluation of what we have done, and we have been projecting our plans for what we should do. We know that our kind of education is original enough to be counted indigenous to our soil; we know we have drawn from other sources, but we have made our education to parallel our industrial production. Sometimes we have feared that we have established educational assembly lines which take in a raw product and shape it for use in industry. Though we do some mass-production, we are not, by any stretch of the imagination, assembly lines. The colleges among us which are worth their keep still know their students one by one. The faculty, that is the good ones, still tailor their wares to the needs of their students.

So different are we from other lands that delegations are coming to us to discover our method of preparing and using engineers in industry. We have much to teach. Also, we have much to learn from all who know.

Evaluation

Two years ago President Hollister sounded the note of evaluation. Since then we have made study. For another year we will continue to study and to seek the direction we should go. By that time we should be able to take the next step in the "scientific-technological" stem (to use the notation of the 1940 and 1944 reports) of our engineering education. Other elements are receiving some general study, but the main motive of the Interim Report is the science and engineering science content.

This is as it should be. Our society has just finished and published a report of the improvement of teaching; it contemplates a study of graduate work and has already set up a plan for study of the other coordinate "humanistic-social" stem.

It will not be a year of evaluation but half a decade of study and evaluation. These are not the first efforts. Since the beginning of our society we have made constant study and appraisal of what we were doing. In every decade the Society has taken a new look at engineering programs with a view to inventory and projection into the future.

Sections and Divisions

Much work may be done by committees organized to make special studies, but these activities do not comprise the major activities of the society. In every subject matter field and in every geographical area there have been organized divisions and sections. These provide a forum for discussion and conferences and an opportunity to exchange ideas and experiences over very wide interests. We believe that the divisions and sections should be strengthened wherever possible. Where a division can make a study of an educational problem, the division should be charged with the activity. Special studies should be used to strengthen the whole society and especially the divisions and sections.

Locally the sections play an important part in our work. Fortunately, the education of engineers is not a local problem. Graduates in Tennessee may work in Maine or California, while graduates in Maine may work locally or in Minnesota or Texas. All the colleges are educating for work in any of the states or in any other nation. Local activities may, therefore, be keyed to the general themes studied by the society as a whole. An excellent example of this coordination has been exhibited during the last two years by programs of the local sections on evaluation of curricula, and the more than 120 reports from the engineering colleges themselves.

Let us strengthen the divisions and sections and thus bring the opportunities of the society to all the members both in subject matter fields and in local geographic areas.

Professionalism

An engineer is more than "one who directs the great sources of power in nature for the use and convenience of man"; he is a citizen of the community, the state and the nation. During the last fifty years much has been done to foster general recognition of the engineer as a professional practitioner. He not only builds a railroad, a bridge, a transmission line, a machine or a factory, but he evaluates their place in the life of today. His vision must not only comprise things and their use, but people and their living. He and the scientist have added quantitative thinking to the qualitative thinking of the philosophers and preachers.

The society must place more emphasis on professional concepts and professional activities. Our committee on ethics is doing a good work. We must realize that learning must be more than a veneer, that service must be real, and that the relation of confidence must be respected. These qualities distinguish a professional. They are taught by contact and contagion as well as by classroom assignment and laboratory exercise.

The committee on ethics is calling from the housetop that engineers must rededicate themselves to right living and noble practices:

> I was young and now I am old, and I have never seen the righteous in want or his children begging bread.

is as true today as when written by the Psalmist nearly three thousand years ago, and yet each generation must be reminded that "as a man thinketh in his heart, so is he."

In our teaching, in our section activities and in our committee work we should be constantly reminded that a profession consists of those who have special technical knowledge, who live by the service motive, who respect the relation of confidence and who follow a recognized code of ethics.

Educating the Whole Man

Our teaching objective is a citizen, a worker and a professional practitioner. Young men and women must be placed in an atmosphere where they will develop the spirit, the attitude and the approach of the engineer. It is not years of study or subject matter that measure the growth but intellectual maturity and professional development; these are important. In a community of scholars, where there is love of learning, the beginning engineer will find a climate which will warrant his spending time and studying subjects revered by his teachers. We should advise our students to spend the years, and to study the subjects, which will contribute most to their intellectual and professional maturity.

We travel on a journey with our faces to the eastward, toward the rising sun. As we travel we discover new lands, new ideas, new methods, and some of us must tarry to occupy and develop the new discoveries. Now and then we reach a knoll where we can look backward to the pathway we have traveled, and by the vision we are spurred to new efforts and new longings, always toward the rising sun.

As we urge our students on the way, it must be done with vision and enthusiasm, that they, as they travel, may perform their assigned tasks with requisite knowledge, judgment and skill.

Education for a Creative Professional Life

By L. E. GRINTER, *President ASEE, 1953–54*

(Presidential Address, Annual ASEE Meeting, Urbana, Illinois, June 15, 1954)

Introduction

This address will deal wholly with the subject of education—with engineering education as its central theme. However, as one grows in educational experience, he learns to view his own professional field as but one face of the many faceted jewel that every student's education should represent. It is futile to polish one face of a jewel while its many other faces remain no more attractive than common stone. Our product, the professional graduate, is still a jewel in the rough unless we contrive that he shall both reflect and refract light that may fall upon him from many directions. Since professional graduates will be bathed in the light from many sources they must learn to reflect or reject the non-essential, to refract or receive the useful and finally to absorb the significant.

If professional education is to attain the objective of educating the whole person it must start with the grades and continue until retirement. Of this lifetime of education, engineering teachers can by personal direction influence from four to seven years. Indirectly, their influence controls the success of the continuing educational process that extends far into the future. It is an appropriate objective for the American Society for Engineering Education to interest itself in all phases of the education of engineers from secondary study to graduate work and into the area of self-education after the termination of formal study.

An Active Year of Evaluation

The year 1953–54 was designated a Year of Evaluation and it has indeed proved to be so. The work of the Committee on Evaluation of Engineering Education has progressed steadily. During the year the Preliminary Report on Evaluation was mailed in October and the Interim Report was published in June. Some 120 institutions analyzed the Preliminary Report so that their comments and viewpoints could be taken into account in the preparation of the Interim Report. It is the desire of the Committee on Evaluation to have an equally wide consideration given to the Interim Report as a basis for preparation of a final report about a year hence. ASEE appreciates the aid of ECPD, of the Engineering Foundation and of the General Electric Company, each of which has contributed to the cost of the Evaluation Program.

Another evaluation study of great significance has been undertaken by ASEE with the financial sponsorship of the Carnegie Foundation. This is the Humanistic-Social Research Project under the direction of Dr. George A. Gullette with Dr. Edwin S. Burdell acting as chairman of the steering committee. This two-year investigation will attempt to evaluate the results brought about by the Hammond Report on "Engineering Education After the War" which emphasized the importance of the humanistic-social stem of engineering education.

In its investigation of engineering education the Committee on Evaluation raised the basic question whether the time had not been reached when modern physics should become a normal study for engineers. Through contact with the American Association of Physics Teachers a study has been encouraged of this im-

portant problem by departments of physics. Engineering deans have been asked to cooperate with any study that may occur on each campus under sponsorship of AAPT. As a contribution to our understanding of the basic problems involved in teaching certain concepts of modern physics to engineers ASEE has joined with the National Science Foundation in sponsoring two Summer Institute Symposia entitled Nuclear Physics in Engineering Education and Solid-State Physics in Engineering Education. It is believed that a comparable conference on Mathematics in Engineering Education can be arranged in due course.

The next related phase of the Evaluation study as visualized by the Committee is to determine the objectives, standards and desirable approaches to graduate study in engineering. The Division on Graduate Study has been encouraged to plan such an investigation and to prepare a proposal that can be presented to an appropriate foundation or to industry for financial sponsorship. It is worthy of mention that the grants to ASEE for the Evaluation Committee and for the other studies that have grown out of its work have already reached nearly twice the annual dues of ASEE members. In this way ASEE has been able to increase greatly its service to American education in the field of engineering. Further details of special activities of the Society will be found in the Secretary's Report.

Significant Influences Upon Engineering Education

Engineering education is the product of a large group of influences that are brought to bear upon engineering faculties. The two most obvious influences are the public school system from which engineering education draws its students and the employing group that accepts the resulting product. Actually, however, these are only two of a long list of influences, including such factors since 1940 as the needs of the several armed services. Of a different character is the academic tradition stemming from the liberal arts and science background of engineering education and the influence of the profession of engineering as exerted through licensing laws and the accreditation process. The influence of the public is in no sense inconsequential. Public opinion is exerted through appropriations to tax supported institutions and gifts to private colleges, through public health and safety legislation that requires specialized engineering services, and even more directly through the effect of public opinion, or regard, as it produces an incentive for young men and women to attain the distinction that the public places upon the profession of engineer.

The Public School Question

One of the major factors that necessarily influence the character of engineering education is the quality and quantity of secondary school preparation. In the viewpoint of those who measure these factors by the capacity of entering students to pass subject matter tests in mathematics and science, a continuing loss certainly is taking place. Whether there may be compensating factors that can contribute to engineering education if they are recognized and utilized is the corollary question. One must not forget that the revolution that changed our elementary and secondary schools from institutions that taught the three R's followed by such tough academic subject matter as English composition and mathematics into the progressive concept of preparation for life through social study and group activity has extended over thirty years. This ground could not be recovered quickly even if the present public discussions and debate should result in a counter-revolution. An entire generation will inevitably proceed from secondary schools to college under the strong influence of progressive education essentially as now constituted.

Of greatest concern to engineering teachers, I believe, is not the loss of subject matter content that the high school

graduate presents for college entrance, but the lack of development of the rigorous thought processes that accompany the study of mathematical analysis, English expression and the logical methods of science. High school advisors seem more and more inclined to discount the value of rigorous courses such as mathematics even though employers regularly point out that the ability to write clearly and to make simple mathematical calculations accurately are the most useful tools that the high school graduate can bring to industry or business. At one time educationalists resisted the requests of universities for such basic training on the theory that only a small percentage of high school graduates would enter college but that all high school graduates must be taught to live and to earn a living. This argument has now lost weight as more and more high school graduates enter college and as employers make it clear that the same academic subjects needed for college entrance provide the most direct contribution to industrial or business life and to the process of earning a living. These are English, history, mathematics, science and other academic rather than vocational subjects.

Teacher training is the process of teaching an art comparable to the practice as contrasted to the science of engineering or medicine. The social science behind the art of teaching is in its infancy compared to the great development of the physical sciences supporting engineering. Hence, the procedures of good teaching must be discussed largely in terms of personal experiences. This leads to the drawing of generalizations from the experiences of individuals which is not an unacceptable procedure but is a one-sided approach to truth. After a future teacher has been exposed to this method of investigation through many undergraduate and graduate courses, he may accept it as an essentially universal method of arriving at truth. Of course, in science there are other ways of establishing truth or lack of truth. We may develop an hypothesis and show by mathematical analysis that a contradiction is or is not involved. We often start with an established principle and by mathematical or physical analysis derive new principles for use. We may make controlled experiments in physical science and draw conclusions with definiteness and assurance that is never possible when dealing with human beings. A student whose education has been confined largely to the broad study of relations between human beings may be wholly untrained in the basic methods by which knowledge or truth is sought in other than the social fields. When such an individual becomes a teacher he can usually influence the methods of classroom teaching and even the subject matter independently of the course title under which his teaching is conducted. Naturally, such an individual is likely to place emphasis upon those areas where knowledge is sought by observation and exchange of experiences rather than upon an area where truth must be determined by the rigorous disciplines of exact physical measurement, mathematical analysis and scientific logic. Such must be the explanation behind a recently published examination in biology, concerned mainly with the subject of football, and similar impostures.

The above is a partial explanation of the lack of emphasis in the secondary schools upon mathematics and science courses but it fails to explain the neglect of written English. Probably the latter is explained by the extreme emphasis upon discussion in groups that is a credo of modern education. Great talkers often have not disciplined themselves sufficiently to learn the rules of correct written English. Hence, if the teacher is trained to do most of his personal thinking in discussion groups, he may feel constrained to use the same method with his students since his own ability to understand and criticize written English may not have been sufficiently developed to make it a part of his professional interest.

Of course, all methods of communica-

tion are of great importance in engineering. We should recognize a real accomplishment of modern education in the growing evidence that our students find little difficulty in participating in discussion groups or in orally presenting their ideas or in delivering a speech. We should look very carefully for evidence that the humanistic-social stem of engineering education may become greatly strengthened by pre-college studies conducted under progressive education. If it should be established that the humanistic-social interests of the student can be developed before admission to college, to the extent of becoming self-perpetuating, engineering education could be redesigned without great loss to supplement the other weaknesses of secondary education that are so evident to engineering educators. We should take a practical view of the secondary school situation which can only be changed over a long period of years and only after a change in philosophy has occurred within the training centers which are the colleges of education in our own institutions.

A Fallacy in Engineering Education

At this point I should like to discuss what has always seemed to me to be a grave fallacy in engineering education. This is the almost universal assumption that we can and, therefore, we must try to accomplish everything for every student. It is clear that this philosophy has two main sources; one is the influence of the faculty's specialized interests and the other is a deeply rooted desire to produce well-rounded engineering graduates. The result, however well intended, is not, I believe, in the broad interest of either the engineering profession or the graduates themselves. One can remember when electives were chosen freely by the engineering student. The pressure to accomplish everything for every student has restricted the free choice of electives until the end result is essentially a fixed curriculum for each student after an initial choice has been exercised.

The objection that is properly raised to the fixed curriculum is that engineering students are individuals rather than cogs. They have radically different interests and will serve radically different functions in society if given the opportunity to express and develop their divergent interests. Such interests range all the way from the spokesman or technical writer to the construction boss. We are dealing with such diverse personalities as future editors, promoters, designers, researchers, contractors, production men, patent lawyers, and entrepreneurs. It is a mental strain to conceive of such unlike individuals profiting equally from the study of any curriculum, but without electives it becomes patent that the college rather than the student must have been the main consideration.

An elective system to become significant must provide a truly free choice of electives. The assumption is made in the Interim Report on Evaluation that twelve per cent of the curriculum, equivalent to one semester of study, can be provided in free electives. Of course, such electives should be selected under guidance so that a scattered, uncoordinated result can not occur. However, the Committee would encourage concentration, by free choice of electives, in one or two of the following fields—humanistic-social studies, management, mathematics, basic science, engineering science, engineering analysis and preparation for design, thesis or practical technology. Any realistic combination of such elective studies leading to a planned objective would be an appropriate capstone for the undergraduate program.

Integration of Curricula Through Science

The history of engineering education could be written as a sequential development of new curricula. Even the ECPD list contains nearly twenty major curricula and a large number of accredited options. This splinter action was mentioned in the Wickenden report of 1930, and it was predicted that the trend toward new curricula would be reversed, but

this did not prove so. The centrifugal action encouraging a subdivision of curricula, development of new options, etc., is still present within the concept of specialization.

The subdivision of curricula has been supported up to the present by increased numbers of students. However, no predicted increase in students within the lifetime of the present generation of teachers is expected to exceed the enrollment of 1950. Other factors also seem to mitigate somewhat against new curricula. One such factor is the growing importance of science in engineering research and, in fact, in every phase of engineering activity. The common science background of engineering may be subdivided into the basic sciences of chemistry and physics, which depend upon mathematics, and the engineering sciences which have been listed by the Committee on Evaluation as statics, dynamics, strength of materials, fluid flow, heat flow, thermodynamics, electric currents, fields and electronics, physical metallurgy and the properties of engineering materials. It seems clear that basic science and engineering science as they grow more and more important in engineering may provide the cohesive or integrating influence that could draw all curricula closer and closer together. If some one hundred hours for scientifically oriented curricula of the four-year type might be looked upon as a common stem, as was suggested in the Interim Evaluation Report, then the opportunity really does exist to reverse the splinter process. The common requirements of basic and engineering science plus the humanistic-social studies may become the integrating factors.

By this it should not be assumed that the Committee on Evaluation recommends that one hundred hours of all four-year curricula should be identical. Instead of such standardization, the Committee recommends experimentation with all possible methods of orienting curricula more significantly toward basic and engineering science. Nevertheless, the evidence is strong that about a hundred hours are needed for the common background of science, engineering science, technology, and humanistic-social studies required by all engineers and that a semester of free electives is essential to permit effective individual development of the student, including some opportunity for educational preparation toward such selective functions as management, research or operation. Hence, it seems less probable that additional splinter curricula will develop in the future if variations are largely restricted to the remaining semester of study that exists within a four-year pattern. Perhaps there may even be some drawing together of similar curricula or options at the undergraduate level with specialization advanced into graduate study.

The Relation of Graduate and Undergraduate Study

The relationship of graduate and undergraduate study in engineering deserves formal consideration by ASEE. Also, standards of quality need to be established in the field of graduate work. For example, if it should appear that the accrediting process might have to be extended at any time in the future to the field of graduate study, ASEE should be prepared to say that the factors of significance in measuring the quality of graduate work have already been agreed upon. If this should not have been done, the opportunity would exist for another agency, which might not even be associated with the engineering profession, to impose standards upon engineering education.

We have available the Manual of Graduate Study in Engineering first published by a Council Committee of ASEE in 1945 and revised by a second such Committee in 1952. It contains careful thought that will be of great use in the process of evaluating the success of different approaches to graduate study in engineering. However, what we now visualize as needed is of a somewhat different character. It appears that a survey of the pres-

ent status of graduate study in engineering based upon statistical data and inspections of graduate programs followed by a comparison of the observed results with the procedures recommended by the Manual of Graduate Study would be of great value. After such a study it should be possible for the committee responsible for steering the investigation to draw conclusion regarding the objectives and standards of graduate study that could be discussed by all engineering colleges before acceptance and would then result in strengthening graduate work on a national basis.

Since a large part of graduate study in engineering is directed toward the production of research engineers, development men and creative designers, it is evident that it can be based effectively upon the professional-scientific type of undergraduate curriculum. Of course, graduate work in industrial management is of a different character and should be analyzed from a different viewpoint. Nevertheless, most graduate study for engineers should emphasize basic science and engineering science. It should usually be based upon a knowledge of mathematics beyond undergraduate requirements for engineers. The conduct of such work at an advanced level requires a teacher with science and research interests as well as a knowledge of practice. One may conclude, therefore, that the qualifications of the faculty, particularly in the direction of mathematical and scientific competence, including productivity in research or other creative work, represents the most significant institutional qualification for the conduct of graduate programs in engineering. It is in this direction that the attention of administrative officers in engineering colleges that offer graduate programs should be directed during the extensive recruiting of new faculty that will be necessary during the next decade.

The Feeling of the Future

Engineering is in the process of taking its place as one of the great learned professions. However, since engineering has grown out of the industrial arts there are vestiges of that tradition clearly evident in present curricula. As the development of science continues, the necessity that engineers be fully capable of applying scientific knowledge will inevitably reshape engineering curricula. Another influence in the same direction is the permanent shortage of engineering talent, particularly of the professional-scientific bent. However, engineering practice will remain an integral part of engineering study since art and science are mixed inextricably in every engineering design. The high usefulness of a knowledge of practice by the teacher is in illuminating the applications of engineering science to design as related to the creative function in engineering.

Since we are free to decide to look even beyond the next decade or so, it seems rather safe to predict that graduate work in engineering will become relatively very much more important in the total educational process. As basic science and engineering science continue to advance, a time will ultimately be reached when a four-year undergraduate education will no longer provide a sufficient basis for the development of ability to conduct professional engineering practice. A choice will then need to be made between extending undergraduate curricula or making professional status dependent upon the acquisition of an advanced degree. Considering the service that four-year undergraduate curricula perform in providing a broad education of use in many vocations it seems unlikely that such curricula will disappear. Hence, the acquisition of an advanced degree may ultimately become the first stage of recognition in the profession of engineering. We have been slothful in recognizing the future importance of the master's program and in developing high standards for its conduct as a basic contribution to the strength of the engineering profession.

The greatest weakness of engineering education has been neither the neglect of

practice nor of specialized science but insufficient attention to welding these together so that the student can explain the rules of engineering art or practice from his scientific knowledge. The student also lacks a sufficient depth of scientific study to enable him to understand the interrelationships between the half dozen or more specialized sciences with which he deals. In addition there has been a lack of understanding that engineering students can follow the road to high professional success only if they learn to accept full responsibility for their own education. Even though examinations that demand ability to originate a solution to a problem are difficult to plan, full of surprises, and often discouraging in the tangible or even measurable results returned, they represent the direction in which engineering education of professional stature must evolve.

Every course taught by a professor of engineering should to some degree carry forward the multiple objectives of professional education; that is, (1) to develop and work from basic principles, (2) to learn how to study after graduation, (3) to make use of the engineering or scientific method without permitting it to become restrictive, (4) to consider every engineering operation as it may influence the public welfare with due consideration of economic limitations, (5) to encourage a willingness to accept responsibility for decisions and (6) to express through individual work the highest ideals of the engineering profession. In large part these characteristics of engineering education apply to all professional education. However, one other characteristic seems paramount in engineering. The engineer must be inherently creative. To be successful he must be sufficiently inventive to bring his work to an optimum conclusion by using a synthesis of theories, concepts, techniques and experiences never before put together in the pattern needed. For this reason all engineering bears a close relationship to research. Of course, we are speaking of important, if not great, engineering, but anything less is inadequate as an objective for engineering education.

In summary, the profession of engineering requires the same elements of education as all other professions, but with greater emphasis upon creativeness. The highest professional education in engineering will weld art or practice with basic science in an approach so fundamental that it will level the walls of narrow professional specialization which have been raised primarily by the pride of craftsmanship. The key to professional education is stimulation of the desire to learn beyond the classroom and the college. This demands the acceptance of responsibility by the student, while in college, for much of his own education through willingness to attempt the solution of new problems. Through such experiences provided under the guidance of those who have themselves carried responsibility, the student will sense his coming accountability for operating in the framework of society for the general good and in the highest tradition of his professional group. The teacher who stimulates such a sense of professional responsibility in his students is a great teacher, deserving equally the applause of his profession and of his university.

ANNUAL MEETING—1955

Pennsylvania State University

State College, Pa.

June 20-24, 1955

Highlights of the 62nd Annual Meeting of A.S.E.E.

By JOHN I. MATTILL

Director of Publications and Assistant Director of News Service
Massachusetts Institute of Technology

One of the duties of the convention press room at each annual meeting of the American Society for Engineering Education is to prepare a summary of the meeting for reporters and editors who could not come. This turns out to be relatively simple. But to prepare a summary for members of the Society—many of whom were at more sessions of the meeting than the writer himself—is a vastly more hazardous undertaking.

Begin with statistics: temperatures at Urbana from June 14 through 18 ranged from highs in the 90's each day to lows in the 70's each night; by Friday A.S.E.E. members had witnessed a new Illinois record for prolonged 90-degree temperatures in June and all were ready to vouch for it.

The annual meeting itself was attended by 1513 men, 487 women, 138 teenagers and children, and (according to the record) 8 babies. The six summer schools were attended by 186 men who were not at the annual meeting. The Instrument Society of America–A.S.E.E. conference accounted for 72 of the 186, the M.E. for 66, Engineering Mechanics for 28, Engineering Economy for 10, E.E. for 8, and the Humanistic-Social Workshop for 2. Excluding babies, the overall attendance at the annual meeting and its affiliated conferences was 2324. Of these 528 were from the campuses of the University of Illinois and 1796 were from outside. Foreign delegates to the meeting totaled 28 men. Foreign wives and children totaled 5.

Clearly, whether or not the babies were included in the total, this was the largest annual meeting in the Society's history. A full schedule of diversions occupied the wives and children while the usual variety of conflicting events confounded their husbands.

Almost 160 members of the Illinois engineering faculty helped to plan and run the 62nd annual meeting, working under the direction of Dr. and Mrs. Lisle A. Rose. And there were 70 others from elsewhere on the Urbana campus, from the Navy Pier division in Chicago, and from among the townspeople, who also pitched in with arrangements. Ten Engineering Senior Student Service Committee Members also assisted.

Focus on Evaluation

The business of the 1954 annual meeting focussed heavily on evaluation. Members urged each other unanimously to devote more time to the basic sciences and to engineering science—at the expense of engineering art and practice.

Industrial representatives, agreeing with the teachers, said that they were unwilling to have colleges sacrifice the sciences and humanities to provide time for studying technology or administration. They insisted that their sales, manufacturing, and operating departments—as well as their research and development divisions—need engineers with strong scientific backgrounds.

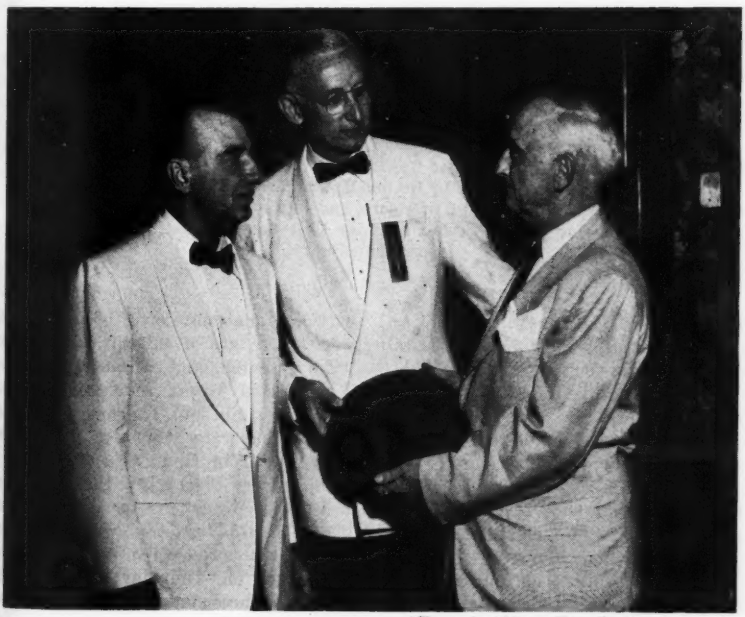
The extent of this move to strengthen science was obvious in the interim report of the A.S.E.E.'s Committee on Evalua-

tion of Engineering Education first distributed during the meeting. Here was a proposal to have all engineering students—no matter what the field of their major—study in common almost five-sevenths of their total course. Only two-sevenths would be concentrated in the field of the major, and almost half of this would be as professional electives.

"The extension of our knowledge of basic science has opened doors to vast new areas of engineering endeavor and has expanded the foundations underlying many of the existing engineering fields. The response of engineering educators to these challenging developments of modern science will have a vital influence upon the course of engineering progress in this country," said the report.

This familiar theme was sounded again by S. B. Ingram, Director of Education and Training at the Bell Telephone Laboratories, Inc., at an electrical engineering conference on Thursday. "We are trying to provide our student with a kit of tools he will need in furthering successfully a career in creative technology. The technology in which he works gets every day more complex," said Dr. Ingram. "To work in it he will need tools appropriate to the more complicated job. He must be grounded to grow with his job."

The emphasis on science was continued by Dr. Lee A. DuBridge, president of the California Institute of Technology, whose address at the celebration of the fiftieth anniversaries of the engineering experiment stations at the University of Illinois and at Iowa State College turned out to be a major event of the meeting. "Maintain a close tie with the basic sci-



(Champaign-Urbana *News-Gazette* photograph)

Dean F. W. Trezise of Navy Pier presents a bronze plaque to retiring president L. E. Grinter at the annual banquet of the ASEE. Looking on is Major Lenox Lohr, President of the Museum of Science and Industry, speaker for the occasion.

(Champaign-Urbana *News-Gazette* photograph)

The new President of the American Society for Engineering Education, Dean Nathan W. Dougherty of the University of Tennessee (left), receives congratulations from two colleagues. At the right is Dr. Linton E. Grinter, Dean of Graduate Studies at the University of Florida, retiring president, and in the center is Dr. Leo J. Lassalle, Dean of Engineering at the Louisiana State University, elected vice-president for the coming year.

ences," was Dr. DuBridge's advice. "An engineer, after all, is putting to practical use today what scientists discovered yesterday." The work they must do tomorrow, he said, will grow out of what the scientists are working on today.

"The main purpose of science," said Dr. DuBridge, "is not to produce bombs and guns and radar—or even radios, refrigerators, and color television, but to advance human understanding."

(Thirty-nine professional and scientific societies named official delegates to this golden anniversary celebration. At least 900 members at the annual meeting visited a special exhibition of Iowa and Illinois experiment station achievements: network analyzer, uses of agricultural wastes, strength of culverts, highway material research, and vibration of curved beams from Iowa; reinforced concrete research, studies of railroad rails, betatron, boiler water treatment, and sound recording from Illinois.)

To further strengthen the sciences as a foundation for engineering education, Professor B. E. Meserve of the University of Illinois suggested at a mathematics conference on Thursday that engineers take these three steps: try to bring mathematics and education together; support high school programs and teachers in mathematics; and support programs to better prepare mathematics teachers.

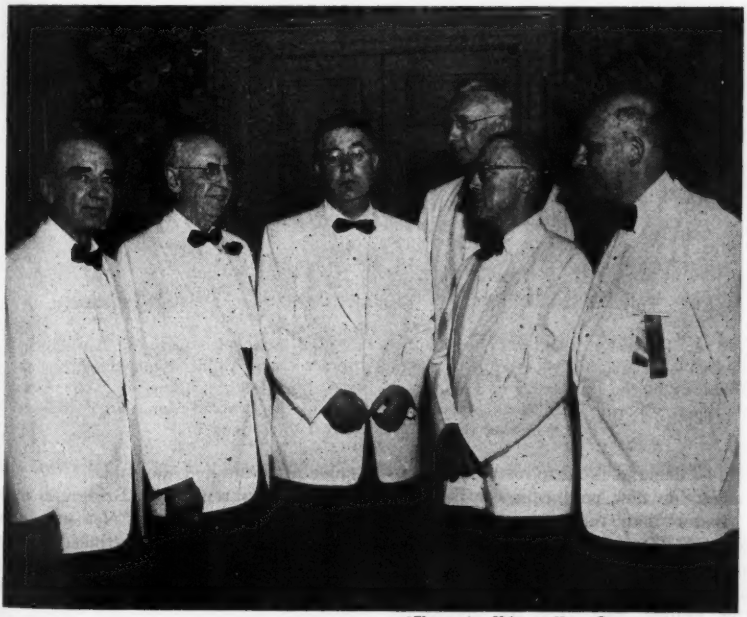
Dean Eric A. Walker of Pennsylvania State University, in his annual report as chairman of the Engineering College Research Council, said that "the colleges of engineering of the United States must get into atomic research if they are to support and conduct a vigorous and up-to-date educational program preparing for careers in the general field of atomic energy."

Still another aspect of evaluation came into focus when Dean Harold L. Hazen of M.I.T. said at a Wednesday afternoon E.C.A.C. conference, "The quality of its faculty is the basic, all-important determinant of quality at any school. This is also the most hazardous and difficult quality to appraise."

The evaluation project which sparked so much of this 1954 annual meeting received a special salute from President Lloyd Morey of the University of Illinois. "One of the most impressive of your activities," President Morey said in greeting the General Council, "is your promotion of high standards and the establishment of effective means of maintaining those standards."

Other Highlights

The local committee at the University of Illinois believed it could count 176 separate meetings, conferences, and sessions for which room and meal arrangements had to be completed. Not all these were concerned with subjects related to evaluation though the majority may have been. Other highlights were:



(Champaign-Urbana *News-Gazette* photograph)

Head Table Principals pose at the Annual Banquet: Left to right are Major Lenox Lohr, Museum of Science and Industry, Chicago, speaker for the occasion; President Lloyd Morey, University of Illinois, Dr. T. J. Higgings, Westinghouse Award winner; Dean L. E. Grinter, retiring President of ASEE, Dean Thorndike Saville, recipient of Lamme Medal; Dean W. L. Everitt, University of Illinois.

(Photo by Champaign-Urbana *Courier*)

Lee A. DuBridge (center), President of the California Institute of Technology, inspects the original betatron at the 50th anniversay exhibit commemorating the founding of the University of Illinois and Iowa State College engineering experiment stations. George Town (left), associate director of the Iowa Station, and F. Wheeler Loomis of the University of Illinois look on.

1. The demand from industry and government for new engineers continues to be greater than the current supply of graduates. Donald S. Bridgman of the American Telephone and Telegraph Company, reporting latest Manpower Committee figures, said that the decline in business activity and defense orders in 1954 has led to a 20 per cent decrease in the need for engineers. But, he continued, "with the relatively small classes graduating at this time, there is still substantial unfilled demand."

"It is apparent," Dr. Bridgman noted, "that the most important elements in this problem can hardly be reduced to numbers. Underlying all of them are the critical international situation and the demands which defense may create." In this connection, Dr. Bridgman pointed out that Russia is estimated to have graduated 43,000 engineers in 1953; the similar figures for the U. S. are 24,000 in 1953 and only 19,000 in 1954.

2. The Graduate Studies Division made a special study of the supply and demand for advanced engineering students. Dr. Henry H. Armsby of the U. S. Office of Education reported that graduate degrees in engineering increased six-fold in a 20-year period from 1929–30 to 1949–50 –and since then have declined slightly. In the case of doctor's degrees only, there has been a steady climb—even since 1949–50.

But, said Professor D. F. Peterson, Jr., of Colorado A. & M. College, the need is still greater than the supply. He listed two factors of "primary importance" in producing more graduate students: improvement in pre-college preparation for engineering and the sciences; and more inspiring scientific leadership, especially in the secondary schools but also at the undergraduate levels.

3. The elusive question of good teaching was before the E.C.A.C.'s General Session on Thursday morning, and the

A conference on international relations was sponsored June 17 by the ECAC at the 62nd Annual Meeting, ASEE, at the University of Illinois. Seated, starting from the left, are Leeds Gulick, Works Study Program, Foreign Operations Administration; Fred K. Bollman, Development and Management Section, Foreign Operations Administration; Joseph M. Roland, Chief, Specialists Division, International Education Exchange Service, State Department; Dean Arthur Hamilton, University of Illinois; H. T. Maser, Foreign Student Director, International General Electric Company; W. J. Holmes, Allis Chalmers Manufacturing Co.; and Joseph A. Cushman, U. S. Division of Immigration and Naturalization, Chicago. Standing are Reinhold Schairer, European Production Activity Agency; Dean F. M. Dawson, State University of Iowa; Dean Harold L. Hazen, M.I.T.; and R. P. Sinha, School of Mines of India.

(Photo by Champaign-Urbana *Courier*)

Notables at the meeting at the University of Illinois of the ASEE are shown inspecting the University's computer. Left to right are Prof. John P. Nash; President Lloyd Morey; Maj. Lenox Lohr, Chicago Museum of Science and Industry, speaker at the annual banquet; Dean L. E. Grinter, retiring president of ASEE; Dean M. L. Enger, emeritus, of the University of Illinois College of Engineering.

results came in threes: Dean R. L. Sweigert of Georgia Tech listed three factors for improving and maintaining good teaching: specific graduate school training for prospective teachers, continuing specific training for new teachers on their jobs, and careful recognition of good teaching wherever it appears. Professor E. C. Thoma of Purdue University listed three "munificent gifts" which make a good teacher: "professional esprit, the zest and the zeal to do a good job"; traits of personality, insight, sensitiveness, and perspective; and an ability to cast reflections of his earlier years forward to light the path of his students. And Richard W. Schmelzer of Rensselaer Polytechnic Institute said these three abilities mark a good teacher: to understand the purposes of his student, to use concrete illustrations on almost any problem, and to maintain the organization of his material from the beginning to the end of a course.

Mr. Schmelzer, as chairman of the Committee on Incentives for Good Teaching, proposed this formula for better teaching: "We need to create a climate of opinion so that the man who devotes himself primarily to teaching won't feel apologetic about it; won't feel that he is playing second fiddle to a researcher or a writer of textbooks; won't feel that he is not a valued member of the university community; won't feel, indeed, that it is somewhat futile to devote his efforts to

making himself as good a teacher as he possibly can."

4. A new plan to give foreign engineering students a chance to take summer jobs in American industry had its first public discussion at an E.C.A.C. International Relations Committee Conference Thursday afternoon. Dean F. M. Dawson of the State University of Iowa and Dean Hazen of M.I.T. proposed that foreign students earn part of the expenses of their schooling by working in selected American industries during vacation periods. While doing so, the students would learn at first hand what the American industrial system really means.

5. "The greatest single challenge facing the engineering profession today," said Cornelius Wandmacher, chairman of the Professional Training Committee of E.C.P.D., "is the professional development of young engineers in the first few years after graduation. It is a matter of greater concern as we demand higher and higher standards of performance in the engineering profession."

At another session on professional development, Professor A. S. Levens of the University of California (Berkeley) pondered the need to help engineering graduates attain higher professional stature by making available to them a variety of planned sequences for advancement in design, production, management, and other fields.

6. An urgent plea for more American young people to enter careers in engineering and technology came from Major

(Photo by Champaign-Urbana *Courier*)

Happy splashing during Champaign-Urbana's week of heat was made by youngsters of ASEE delegates during their special hours in Bevier Hall pool. Left to right are Maxine Jo Roth, 9, New York City; Melisa Merian, 8, Berkeley, Calif.; Sandra Huss, 7, Cogga Falls, Ohio; Bill Snyder, 9, Royal Oak, Mich.; Juan Sanchez, 8, Puerto Rico; and Bruce Williams, 8, Urbana.

University of Illinois engineering wives prepare favors for women's events held during 62nd annual convention of the American Society for Engineering Education.

Lenox Lohr, president of the Chicago Museum of Science and Industry, speaking at the annual banquet on Thursday.

"Careers in science and engineering must be sold to young people in increasing numbers if the future welfare of our country is to be served," he said. "Its success will depend on how well these professions can be dramatized. This task is the great new responsibility of educators in the engineering field."

Major Lohr pointed out that only 15 per cent of today's high school students in Chicago study algebra, only 4.9 per cent chemistry, 4 per cent physics, and 1.5 per cent solid geometry and trigonometry. "More young men and women," he insisted, "must be inspired to take technical courses. We must place our emphasis on the basic sciences in the lower grades, and teachers must develop the techniques of making science enjoyable and practical."

"Uninspired and inept instruction have too frequently made these all-important subjects a nightmare for the student," Major Lohr declared. "The teacher should emulate the good salesman: be convinced of his subject's importance, know that his student has a vital need which he can supply, and induce the student to really want it by employing all those devices which make it most palatable and persuasive."

Penn State Next

The gavel presented to retiring president Grinter at the annual banquet was made at the University of Illinois of wood originally part of the Fine Arts Building at the 1893 Chicago World's Fair. (A.S.E.E.'s predecessor organization was founded at the Engineering Congress of that World's Fair.) Vatican architects, instructing that the building housing Vatican art treasures sent to the

Fair be "fireproof," specified wooden columns three feet square. The gavel was made from one of these, and enough wood was left over to supply similar gavels to eight former presidents of A.S.E.E. who had somehow failed to receive gavels at the end of their terms. The Chicago Museum of Science and Industry is the present occupant of the Fine Arts Building, and the wood for those gavels was presented to Illinois by Major Lohr after it came to light during a recent remodelling.

The daily bulletin published at the 62nd annual meeting confidently announced on Wednesday morning that Professor A. M. Fountain of North Carolina State College, who hasn't missed an annual meeting during the past 20 years, held an attendance record. By Thursday morning the bulletin discovered that Dr. Armsby boasted 21 consecutive meetings, 1931 to date. The balloon burst completely at the annual banquet Thursday evening when Dean Grinter quietly commented that he was that evening attending his 25th A.S.E.E. banquet.

This argument will probably continue next year at the Pennsylvania State University, June 20 to 24, when each of these contenders will have added one year to his record. Dean Walker was heard to state that "it's always cool at Penn State," but nobody was sure whether this was sound salesmanship or rash boasting.

College Notes

A chair in mechanical engineering has been established at **Stevens Institute of Technology** in the name of George Meade Bond whose development of accurate standards of measurement has been credited with making modern mass production methods possible. The chair is endowed under a bequest of more than $300,000 in the will of Mrs. Ella Kittredge Gilson of Hartford, Connecticut, who died last November, according to an announcement by the Hoboken, N. J., engineering college.

Dr. H. P. Robertson of the **California Institute of Technology** has been appointed scientific advisor to Supreme Headquarters, Allied Powers, Europe (SHAPE), headed by Gen. Alfred M. Gruenther, Supreme Allied Commander in Europe. He is taking a year's leave of absence as professor of mathematical physics at Caltech.

Plans for a nuclear reactor to be privately financed and devoted solely to education and non-secret research in the peacetime applications of nuclear power were announced by Dr. James R. Killian, Jr., President of the **Massachusetts Institute of Technology.** The first nuclear reactor, planned for construction in New England, Dr. Killian said, will be used in an everwidening search for fundamental knowledge and for the solution of engineering problems in the new and promising field of nuclear engineering. Coupled with this new reactor are plans for a new building for the physical sciences.

George A. Hawkins, professor of thermodynamics, **Purdue University,** has been nominated to serve as a director-at-large of the American Society of Mechanical Engineers.

Education for Creative Leadership*

By MAJOR LENOX R. LOHR

President, Museum of Science and Industry, Chicago

The form and content of education best suited to give our children a full and successful life has, from time immemorial, been a subject of controversy, of constructive criticism and of constant efforts to improve its effectiveness. This is inherent, for there is so much to learn and so little time to learn it. Of the scores of subjects that might be pursued, there is time for only a relative few, and, due to changing fashions, the needs of the time, or to the predilections of the school administration, the curriculum may or may not include courses which would be those most valuable to the individual in later life.

Of transcending importance, however, is the method of presentation of any course, for, by its inspiration or ineptitude, there either is or is not inculcated in the student a desire for more education, an ability to think clearly and reason correctly, and an appreciation of the fact that the courses pursued are not merely academic abstractions but actually the tools with which to carve a future career. As education is made a pleasurable and satisfying experience, rather than a dreaded chore, its effectiveness will be increased proportionately.

The engineering colleges have a keen appreciation of their responsibilities and are fully aware of their still-unsatisfied needs. This is evidenced by the large attendance of our foremost technical educators at this meeting of the American Society for Engineering Education and by exhaustive reports of your committees. This group would be the last to contend that the goal had been reached.

The science of engineering began in the early 1800's on an academic foundation. It differed radically from the practice of the builders of olden times whose know-how was arrived at empirically. It differed from that of the early lawyers and doctors who "read" law or studied medicine in the office of a practitioner. Involving the basic sciences and theoretical considerations, the science of engineering could best be learned in the classroom from instructors especially qualified to impart knowledge in their own specialized fields. There has been a constant striving to meet the technological needs of the times, to incorporate in the curriculum each advance in scientific knowledge, and to produce better-rounded graduates. Our American engineering colleges are doing a superb job in training engineers to be engineers; that is, in cramming as much technical knowledge into those who want to be engineers as they are capable of absorbing.

That is not enough. Our continued prosperity, and even our very existence as a nation, may depend upon members of this Society going far beyond your green campuses and doing a job more fundamental than any prescribed in your college registers. Ways must be found to induce more youngsters to aspire to careers in technology, and they must be better prepared on entering college.

Critical Shortage of Engineers

We are all aware of our critical shortage of engineers. With less than 20,000 graduates this year, our needs are in excess of 40,000, with the prospect of a greater number required by industry in

* Address given at the Annual Banquet of ASEE, University of Illinois, June 17, 1954.

the years immediately ahead. Our military authorities are justly alarmed for the national security. Modern wars are conflicts of technology, demanding more and better engineers in the Services and in the production of arms. We are rapidly losing the edge which we have had on Russia. Our superior technical knowledge has heretofore offset their greater manpower and supply of natural resources, but the gap is closing. Reliable information indicates that half of the curriculum of the secondary school in Russia is devoted to scientific and technical subjects and that one-third of their college students are taking engineering.

Our national abundance has aroused jealousy and even enmity in other parts of the world. There are those, not being capable of achieving a comparable standard of living by their own efforts, who would like to undermine ours. With 6% of the world's population and less than 7% of the land area, we in the United States make, use, and produce nearly 50% of the world's goods. In three hundred years this nation has progressed from a virtual wilderness to the highest standard of living the world has ever known. How has this been achieved?

America was settled by freedom-loving men of strong faith with the courage to face the unknown and to carve their destiny despite hardship and adversity.

They came to an economic and industrial vacuum, without the restrictions imposed by centuries of precedence and tradition to confine their endeavors. It was a virgin country where they could plan, build, and develop according to their native common sense and initiative. They devised a system of government permitting competitive enterprise with the hope of reward for success and the risk of loss for failure, but with the liberty to try and try again. They built an industrial empire with a philosophy of mass production, that there might be an abundance of goods which most people could afford to buy. With ample risk capital, farsighted and efficient management, a high level of general education, and competent inventors, scientists, and engineers, we have come a long way with amazing rapidity.

Since the year 1900 our population has doubled. And, due to the use of power tools on the farm, the proportion of farmers (to other workers) necessary to feed the rest of the nation has materially decreased since the turn of the century. Due to these two factors, the number of workers available to perform or build all the rest of the services, necessities, and luxuries of life has increased from 17,000,000 to 55,000,000. But this represents only a part of the gain, for during these five decades, the tools and power which have become available in industry have increased the productivity of the worker as much as a hundred-fold.

Every step in this progress has required the services of the engineer. In 1900, there was one engineer to 290 industrial workers; in 1954, the ratio is one to 65. As we extrapolate the curve, we wonder how we can supply the demand for more and more engineers. What can the engineering colleges do to meet this potential crisis? They must go beyond their cloistered halls and work in other fields with the same effectiveness that has accomplished so much in improving their own curricula.

Need More Properly Prepared High School Graduates

A farmer cannot produce a good crop from poor seeds, nor can a skilled mechanic produce good tools from inferior steel. The technical colleges cannot produce sufficient well-trained engineers unless they have an ample supply of properly prepared high school graduates to draw upon. The acute problem really begins at the end of the second year in high school, for, if by this time the student has not made up his mind to pursue a technical career, he is unlikely to take those courses which are an essential foundation for the tough curriculum of the engineering college. Few

youngsters in their middle teens have made up their minds about what they want to do in life, unless it be to pursue some romantic interest popular in the events of the day. Most of them can name scores of ballplayers, movie stars, military heroes, and even some scientists and inventors, but few could name a single prominent engineer or tell who was responsible for a current outstanding engineering project. The problem is how to encourage those with natural mechanical or scientific inclinations but without a realization of their latent aptitudes to consider a technical education.

The engineer has not been glamorized as have those in other professions. He is seldom the hero in a novel, TV script, or motion picture, and rarely appears in the news of the day. There are a number of reasons for this situation. The ethics of the profession frown upon personal publicity, and many engineers consider it beneath their dignity to appear in the spotlight even for notable accomplishments. Engineers do not work directly with the public in the same way as the doctor, the minister, or the lawyer, but in general they are submerged in large corporations, government agencies, and educational institutions.

Many a capable youngster is groping and is uncertain of what he wants to do. What can be done to focus his thinking on engineering? Creative work, service to fellow men and country, the building of great structures, the thrill of discovery in research may offer arguments fine and true, but they are unlikely to motivate the youngster whose mind is partly on the next school dance or on whether he can borrow his father's car.

How can engineering be so dramatized over the length and breadth of the land that thousands of boys and girls who have not yet determined upon an engineering or scientific career will be persuaded to look ahead with enthusiasm to the grueling grind? Argument, no matter how persuasive, must be supplemented by an appeal to the emotions. Appeals to reason may work with an individual or a small group, but with little success with unseen masses, as amply proven by the experience of radio broadcasters. Since audience mail has proven the best way of determining program popularity, all returns are systematically recorded. The ratio of response from appeals to the emotions, as compared to serious broadcasts, indicates a ratio greater than 100 to 1.

A ten-year-old infantile paralysis victim sang "Over the Rainbow" and asked for contributions to the March of Dimes, and 1,393,590 responses came in. Listeners were invited to send a cheery card to a youngster who had been bedridden with rheumatic fever since babyhood. He received over 100,000 pieces of mail and 450 gifts, including train sets and bicycles.

On the other side of the picture, one broadcast on the functions of the United Nations drew 1030 letters, and a similar one at a later date, only 45. A speech by Herbert Hoover on a public issue of national consequence brought in 2998 responses.

Emotional Appeal

A classic example of the emotional appeal was an episode on a radio program entitled "Ma Perkins," a fifteen-minute "soap-opera" serial, running five times a week. Ma Perkins was a homey character with a simple, appealing family, whose experiences were as real to her loyal audience as those of their next-door neighbors. They rejoiced with her successes; they grieved over her tribulations. At the appropriate season, Ma Perkins decided to plant some petunia seeds. She prepared the ground in her little garden, and the seeds were sown. Day by day the audience followed their progress. The ground was watered, the tiny sprouts broke through the ground, the weeds were pulled, the plants matured, and lo, one day a bloom appeared. At this stage the announcer came on the air and said, "How would you like to have some of Ma Perkins' own petunia seeds?"

Let us analyze the results of this simple episode critically. It did not occur to the audience that Ma Perkins, her garden and seeds were a figment of the imagination. They did not visualize an actress reading a prepared script before a microphone, freshly typed by a professional script-writer. They did not stop to consider that, even in character, Ma Perkins would not have had wholesale quantities of petunia seeds. Yet they were motivated to go through the involved process of securing a dime, a box top, and the complications of mailing. When the responses were counted, over 1,100,000 dimes had been sent in, taxing the resources of the seed wholesalers of the country. That appeal went direct from the ear to the heart, and by-passed all mental processes; for had the facts been considered logically, the dimes would have been few. A careful tabulation of the returns showed that they represented a fair cross section of the American people. Appeals to the emotions react on all.

Careers in engineering must be sold to young people in increasing numbers if the future welfare of our country is to be served. Its success will depend on how well the profession can be dramatized. This task is the great new responsibility of educators in the engineering field.

If they appreciated the needs, teachers as far down as the middle grades could also be of material help in fostering an urge for technical careers, especially in those mentally, and temperamentally suited. Many a lad has been lost to engineering through lack of the right appeal in preadolescence.

A Science Fair held last month at the Museum of Science and Industry, the result of a competition among high school students, resulted in over five hundred exhibits, chosen from thousands. Each was demonstrated by the students who designed and built it. These exhibits evidenced an extraordinary knowledge of scientific principles. They ranged from models of reactors and jet engines to collections of butterflies and fossils. The Fair attracted over 26,000 other students on the first of the three days that it was open, many of whom undoubtedly received a real inspiration from it.

There was recently installed in the Museum of Science and Industry, Colleen Moore's Doll House, a fabulous fairy castle costing over a half-million dollars. You might well ask, "What has this to do with either science or industry?" Indirectly, it has a lot, for 100,000 youngsters a year will come to see it who would not walk across the street to see the finest exhibit on science or industry. During their visit they will be exposed to intriguing technical exhibits, and many will have their interest aroused. It is better to proselyte among those not already convinced.

Stimulation of Interest

The stimulation of interest in technology is the primary challenge, but this is only the first half of the problem, for even when successful, it demands a quality of instruction in the third and fourth years of high school, particularly in the basic sciences, that must be adequate to prepare the graduate for his years in college. A recent survey among a large number of high school seniors indicated that the percentage who had taken courses in the basic sciences was alarmingly low: 15.4% in elementary algebra; 1.5% in solid geometry and trigonometry; 4.9% in chemistry; and only 4.0% in physics. Chicago public high schools do not require mathematics as a prerequisite for graduation, and some do not have a single class in physics.

The trouble goes back to the elementary schools, because if the pupil has not mastered such simple fundamentals as the multiplication table and decimals, he is so handicapped that each succeeding course in science becomes too difficult to warrant going further. It is human nature to cherish the memory of a pleasant experience and to draw down the curtain of oblivion on one which was repulsive, boring, or too difficult. Many a student,

on passing his final examinations in mathematics, physics, and chemistry, has exclaimed, "Thank goodness, that's over! Believe me, I would never want to go through that again." Uninspired and inept instruction has too frequently made these all-important subjects a nightmare for the student. His attitude is communicated to his fellows, and they shy away from subjecting themselves to the same ordeal.

With different teaching techniques and a more appealing presentation, the most difficult subjects can be made interesting and enjoyable, and fewer students would fail in their first year at college.

The teacher could well adopt the art of the salesman, a term which would not have an obnoxious connotation if the attitude of the true salesman were better understood. He is neither a peddler nor a hawker. A real salesman is one with high ethical standards, because his stock in trade for repeated sales is the confidence that he builds up in his prospects over the years.

He must know his product thoroughly with all its qualities and limitations. He must conscientiously believe in the merit of his product, for he will make sales, not so much by his words as by the conviction emanating from him. He will thoroughly analyze the needs of the prospect and be the first to recommend a competitor's product if his own brand will not satisfy the need. He believes that his product can profitably supply a need which his prospect may not realize exists. Clearly and logically he presents his case. He refrains from exaggeration, believing with Benjamin Franklin that a mild statement is the most convincing.

Three shoe-shine parlors were established in a single block. The boy at the first corner erected a sign saying, "The best shoe shine in the United States." The one at the other corner, not to be outdone, had his sign read, "The best shoe shine in the whole world." Little area remained for the one in the middle of the block, so his modest sign read, "The best shoe shine in this block."

There are no salesmen behind the Iron Curtain, the public being permitted to buy certain things and ordered to buy others. Too much of this attitude exists in the classroom. The teacher should emulate the good salesman—know his subject thoroughly, be convinced of its importance, know that his student has a vital need which he can supply, and induce the student really to want it, by employing those devices which make it most palatable and persuasive.

Selling is Essential

Selling, in the sense in which I am using it, is essential in all the media of mass education. We have mass education, in some degree, in magazines, newspapers, motion pictures, radio, television, expositions, churches and museums. While the effective techniques of teaching in all these media are essentially the same, they differ radically from those of the classroom. The characteristics of formal education diverge widely from those of mass education. However, they complement each other, rather than overlap or compete.

In formal education, especially below the college level, the students are essentially of the same age and scholastic and cultural backgrounds. Attendance is compulsory and under discipline. The courses are coordinated and sequential, with individual attention from the teacher. There is home preparation, repetition, and competition with fellow pupils.

Those exposed to mass education are of all ages from two to toothless. They are of all educational backgrounds from kindergarten to Ph.D. There is no homework, no competition for marks or parental approval. If there is repetition, it is for things they know and enjoy, rather than for subjects difficult to learn. Yet this heterogeneous group is, in general, exposed to the same things simultaneously.

Since attendance in mass education is voluntary, special ingenuity is required to intrigue interest and make it an enjoyable experience. Use of all the devices of showmanship, drama, and entertain-

ment is necessary to hold the interest of the student. The explanation or demonstration must be so lucid and understandable that the visitor or reader feels a compelling urge to see it through.

In the classroom the student is held physically by discipline, but his mind and attention may have drifted far afield. Restraint is a poor substitute for holding attention, interest, and enthusiasm. He who attends class with pleasurable expectation is more susceptible to learning than he who considers it an inescapable obligation. That which is learned through understanding rather than rote memory will remain as a guidepost when theorems and formulas are long since forgotten. That some gifted teachers are able to accomplish this only emphasizes the lack in others.

I well remember my professor of mathematics at Cornell who conducted an eight o'clock class, six days a week. He had the knack of making real, and applicable to the experiences of life, abstract and academic paragraphs in the textbook. I recall that in a problem involving the intersection of two curves, he described a cottontail rabbit sitting in a hedgerow. A dog enters the field, sees the rabbit and takes off after him. The rabbit runs in a straight line, but the dog, instead of heading him off, runs directly at him and hence on a curve. It took two pages of calculus to catch that rabbit, and, though it was forty years ago, I can still see that hound dog chasing it across the field.

Abstractions, the practical application of which seems to end with memorizing them, would take on a different aspect if tied in to those normal experiences of the student which affect him personally, or if the problem can present a predicament or experience in which, in his imagination, he can make himself a part.

Successful mass education must be so planned that a stimulating interest is aroused on first contact, for normally split-second decisions are made. As we thumb through the pages of a favorite magazine, we pass up several articles until some outstanding picture, title, author or catch-phrase causes us to pause for a second look. As we spin the dial of our radio, something causes us to stop at one station after passing up several others; as we walk through a museum, exhibits on all sides demand our attention, but we see only a few. Something must intrigue our fancy at the first brief glance to invite a try.

Interest Must Be Held

In mass education, interest must be held from *instant* to *instant*, for if it is relaxed, even momentarily, the student cuts class. As we start reading a column in the newspaper or an article in a magazine, the first paragraphs hold our attention, but let the author become inept, inane, or just boring, and we turn the page and seek something new. We may be listening to a radio program with interest, but let the speaker get dull or the interest pall, and that powerful censor, the thumb and forefinger, comes into play and we spin the dial and are lost forever.

In museum exhibits, the greatest educational advantage is achieved by first showing the people what they want to see, for then they are willing to look at what you think they ought to see.

The Museum of Science and Industry in Chicago is an institution for mass education. It is not a museum in the classical sense. It is not a repository of historical objects or of scientific collections in endless rows of glass cases. It endeavors to demonstrate the laws of basic science and their application to industry. Through sequential exhibits which tell a story, it portrays the elements which have made America pre-eminent in production. This year it will be visited by two and a half million people who will spend an average of three hours within its halls. Many of these are organized school groups. Last month in a single day there were 92 schools represented from seven states. It is a healthy sign that teachers are realizing that, while basic education and the ability to think a problem through can be taught

only in the classroom, exhibits demonstrating the laws of science and the methods of industry are essential in rounding out the student's conception of the world in which he lives.

But the real key to the situation is whether the youngster enjoys the experience and wants to come. In a recent article in the *Saturday Evening Post*, the author epitomized the Museum's exhibits by saying, "You wouldn't think that many people would go out of their way to detect the radioactivity of an isotope of strontium, but in Chicago, children cry for it." He referred to a tank of live frogs, some of which had been made radio-active. Visitors could locate the "hot" ones with a Geiger counter.

We have found at the Museum that even the most complicated of scientific concepts, such as those in the nuclear exhibit, can be made clear with the proper demonstration equipment, by a step-by-step sequence of presentation, and by eliminating those unessential details dear to the heart of the specialist. It is particularly necessary to start the explanation on page one. The expert is too likely to assume that the first steps are obvious and familiar to everyone, when actually they may be unknown to those whose interests lie in other fields.

All too frequently textbooks and museum labels are technical gobbledegook written by experts more to impress their associates in the field than to enlighten the student or public.

The textbook definition of the Second Law of Thermodynamics is, "No change in a system of bodies that takes place of itself can increase the available energy of a system." Lord Kelvin's elucidation of the law should make this perfectly clear to the ladies present. He explains, "It is impossible by means of inanimate material agency to derive mechanical effect from any portion of matter by cooling it below the temperature of surrounding objects." Kettering, with the knack of making complicated things simple, says all this means is, "You can't push on something going faster than you are." Perhaps not scientifically inclusive, it at least gives the student an idea to start on, and he can progress to more exactitude from there. "The mind of man is less confused by a mystery he cannot understand than by an explanation he cannot comprehend."

Some time ago we were entertaining a group in the educational field at the Museum. They observed a "mobile," a series of arms swinging in different planes, which was then new. It was purely architectural and decorative and had no other significance. Several inquired what it was. At lunch, with the purpose of being humorous, I described it as a turbo encabibulator, of which "the suspensorial multiple planar ovoids, on their circular swings, exhibit the skor displacements by their stepform-phased reciprocatory excursions. In their amplitudinal range these exponentially damped oscillations deplenerate co-sinusoidally." This was sheer nonsense and gibberish, but instead of the laugh I expected, they nodded their heads in understanding approval.

Important Function

An important function of the Museum is to make real that which the student learns theoretically in the classroom. He may be able to give a parrot-like recitation of a theorem without understanding its application. Incidentally, high marks are sometimes a poor criterion of what the student really knows, for his endeavor to get them may be at the sacrifice of basic comprehension.

Newton's Law of Motion (there used to be three when I went to school) contains eighteen words with two footnotes that explain terms. An average student should be able to memorize it in a few minutes, and be marked perfect on a subsequent examination, yet might have only the vaguest idea of what it means. To illustrate this principle, I described an exhibit to a group of secondary school physics teachers planning tours for their

classes. I asked the group if they knew Newton's Law of Motion. Somewhat taken aback, they allowed that they did. So I continued:

There is a turntable about six feet in diameter, free to turn on its pivot. Around the periphery is a miniature railroad track. When a button is pushed, electric current starts a small train. Then, I asked, what happens? They said that for every action there is an equal and opposite reaction, and when the train moves forward, the track revolves backwards. Correct. Now I continue to hold the button—what happens? Some thought the relative motions would continue, but, of course, when the train reaches full speed, there is no longer the force of acceleration, the track stops and the train continues merrily on. Now, I take my finger off the button, hence cutting off the current. What happens? Silence! As the train slows down, the force of deceleration is in an opposite direction to the travel of the train, hence its reaction being forward, the track starts up in the same direction as the train is moving. They all wanted to go up and push the button for themselves.

They also saw a miniature cannon mounted on a track. While still stationary, a cannon ball was spring-fired vertically into the air and, as was expected, it dropped back into the muzzle of the cannon. Then the cannon was moved rapidly along the track and, while still in motion, the ball was again fired. It performed a graceful curve in the air and again dropped back in the still-moving muzzle of the cannon.

Demonstrations of this kind make an indelible impression and an understanding not possible with words alone.

In the exhibit of the Commonwealth Edison Company, there is a demonstration of the economy of electric power. The public is invited to pedal a stationary bicycle to which is geared an electric generator. Appropriate meters and a glowing lamp indicate the amount of physical work required to produce a given amount of electricity. An unusually strong teen-ager, by exerting maximum effort, can register one-half kilowatt. If he is able to maintain this rate for two seconds he is awarded a metal disc in which is imbedded a one-cent piece. Around the edge is this inscription: "If you continued this rate of work for one hour you would produce one cent's worth of electricity." The recipient can readily visualize that this would be a hard way to earn a living. It would take four husky men to produce a half-kilowatt for an hour, and if they were paid the nominal sum of a dollar an hour, it would make the cost ratio of manpower to electrical power 400 to 1.

No label could carry so effective a message as this personal experience. Exhibits which have visitor participation are the most popular and effective. The visitor does not want to be told. He wants to find out for himself through the use of his own muscle and brain. This is demonstrated by the excessive wear on the carpets in front of such exhibits.

Make Education Fun

While such elaborate equipment is not feasible for the schools, nevertheless, much of the technique of making education fun could be brought to the classroom if the teachers had the willingness and ability to do it. This active organization might do much to further the idea that learning can be fun, to the great benefit of the college, the student and the country.

What I have said thus far applies principally to the primary and secondary grades. What more can be done at the college level?

In former years there was much criticism that an engineering education was too restricted and that graduates were not sufficiently well rounded to progress beyond the narrow confines of the profession. Due to recommendations made by your Society, there are being incorporated in the curriculum certain humanistic-social subjects. These will undoubtedly make for a fuller life and a deeper appreciа-

tion of cultural and spiritual values. If these studies are to be of greatest value, they must be closely integrated to the needs of the engineer.

In later life his salary and advancement will depend not so much on what he knows, as on what he is able to produce for his immediate superior. If he is a good engineer, he will be assured of a steady job, but his promotions will come as he is able to produce more than the company expected of him and as his contributions to its welfare go beyond a routine position.

Second to our need for more engineers is our need for leaders. Some men are born leaders, and many of those with an engineering education rise rapidly to the top. Forty per cent of the principal executives of our major corporations have a technical background, predominating over the lawyer and banker of former years. The administrative ability of the trained engineer is being recognized today and his talent applied to the broad field of management.

But leaders are not being born fast enough to supply the increasing demands of this technological age. We are living in an intensely competitive world, and America can hold its dominant position only by producing more and better leaders to guide our destiny. Here lies a great challenge to the colleges. Potentially, an engineering background affords the greatest opportunity for supreme contributions to our national welfare in whatever field the graduate enters. The college can do much to make that potentiality a reality.

The college can warn the student against the traits of mediocrity. Most people want to be followers; they prefer to take, rather than give, orders. They shun responsibility; they dread making decisions; they watch the clock, rather than put in the extra effort to get a job done; they want security without earning it; they find physical effort preferable to constructive thinking.

The father of a college graduate called up a friend, a railroad president, and requested a job for his son. In a subsequent interview with the president, the boy was asked what he would like to do on the railroad. He wasn't sure, so the president sent him out on the road for a week to look over the various jobs and then come back and tell him what he wanted to do. When the week was up, the young man reported, saying, "You know the man who goes around with a hammer tapping wheels to see if they are cracked? Well, I'd like to help him listen."

In his primary role, the engineer is not a leader, either by training or function. That so many break away from routine to achieve top rank is indicative of the soundness and versatility of a technical training. The colleges have been so intent on making good engineers that they have failed to develop latent talents of leadership. Innate ability or inspiration of the individual, rather than his undergraduate training, has produced the leader.

Sometimes small incidents single out the individual from the mass of his fellows and kindle the spark of leadership. Recognition of a task well done may be just such an incentive. The college should train the engineer to speak well and convincingly in public. It should give him a correct picture of our great industrial empire and what makes it tick. It should not so overburden him with laboratory reports that he feels he cannot spare the time for extracurricular activities. The professor who takes a personal interest in the student can give him an insight into the philosophy of life. He can tell him of the importance of personal appearance and the social amenities. He can fire the imagination with the great opportunities that lie ahead to the one who has the will to achieve.

Engineering Approach

Many of the ills that beset the country today are due to a failure to learn the facts, to analyze a situation thoroughly, and then act on it without fear or favor.

Many of these difficulties would have been obviated if they had been considered by what has been aptly called the "engineering approach." This is a systematic quantitative analysis to determine the relations between cause and effect. The engineer is trained to be certain of his facts and to be sure that he has all of them. He designs with mathematical precision, but has the constructive imagination to foresee difficulties and be prepared to overcome unexpected ones if they occur. He must make ample allowance for factors that cannot be accurately pre-determined. He is trained never to fly in the face of fact through ignorance, cupidity or lack of time or money. He must not gloss over points which affect him adversely or eliminate those which don't jibe with his preconceived ideas. He cannot act on guesses, whims or hunches and he must be without bias or prejudice. He cannot indulge in half-baked dreams or take long chances on unrealistic premises. The engineer has no corner on integrity, but all of his training is designed to make him think accurately and realistically.

If this type of thinking had been applied by our leaders in our diplomacy with other nations, and to the economic and political acts of our government, many of the blunders which have been so costly in lives, dollars, prestige and security, would have been avoided.

The engineer must be trained in public relations that he may go beyond his slip-stick and blueprint and take a broader interest in public affairs and his fellow man. He must learn to sell himself in order to render the real service of which he is capable. He must develop better insight into what motivates people to act, he must have the diplomacy to persuade others to think as he does, and he must have a fuller appreciation of human relations.

He who produces the goods and services of our abundant living should be fully conversant with the factors which have made it possible. Too many college graduates have erroneous ideas on big business, mass production, our competitive enterprise system, and private ownership. Unwittingly, they would tear down that which their liberty-loving and industrious forebears have built. They are so sure in their misconceptions. Kettering says, "It is not what you don't know that is harmful, but what you do know, that isn't so." They must be set aright on the fundamentals of our economic system.

More young men and women must be inspired to take technical courses. Emphasis must be placed on the basic sciences in the lower grades, and teachers must develop the technique of making them enjoyable and practical. Courses for engineers on humanistic-social subjects should stress leadership, public relations, and a knowledge of the factors that have made our country pre-eminent. In producing a well-rounded graduate, the college must train him, not only to be a good engineer, but to be a leader as well.

College Notes

G. Stanley Meikle, research director of the **Purdue Research Foundation**, will become vice-president of that foundation July 1, and will be succeeded in the capacity of director of research by Dr. Ralph A. Morgen, who is currently Program Director for Engineering of the National Science Foundation in Washington, D. C. Announcement of the change was made today by President Frederick L. Hovde of Purdue University, who is also president of the Research Foundation. The change was approved yesterday at the annual meeting of the directors of the foundation. Mr. Meikle will succeed Charles J. Lynn, of Indianapolis.

Goals of Research

By L. A. DuBRIDGE

President, California Institute of Technology *

As the title of my remarks suggests, I am not proposing today to argue about the desirability or importance of research, about its cost or about the shortage of research people or research funds. All these things, before this audience, can be taken for granted.

But I am going to take the liberty of reflecting for a few moments on another subject, which possibly should also be taken for granted; namely, the place and purpose of research in science and engineering in an educational institution.

Clearly, in order that my remarks on this subject should make sense, I must explain what kind of an educational institution I am talking about and I must state my own philosophy of what such institutions should be.

Obviously, I am not going to be talking about either public or private elementary schools or high schools, or even junior colleges. Nor shall I try to encompass the problems of the separate liberal arts college. In fact, in order that I may stay within an area which has relevance to the interests of this audience, I shall speak only of such institutions of higher education which are or which include schools (or divisions or departments) of engineering. On the other hand, I shall also exclude institutions—if there be any such—which include within their curricula *no* offerings *other* than those leading to a Bachelor's degree in engineering. In other words, I shall be talking about research in institutions where both undergraduate and graduate work in engineering (and presumably in science and possibly in other fields too) is being offered.

In fact, as you will see, I am really talking about a university in the sense in which that term was used by the Commission on Financing Higher Education; that is, an institution offering graduate work in more than one professional field. (Under this definition, M.I.T., Calteeh and Carnegie Tech are universities. A separate law school or medical school would not be.)

Now I must admit that I have a highly prejudiced—almost emotional—feeling about universities. I happen to think that they are just about the most important institutions in the Western World. I believe they have made contributions to western civilization—physical, intellectual and spiritual contributions—which are beyond the power of any man to compute or to comprehend. And I believe that the nature of the civilization that our grandchildren will inherit on this earth will depend in a critical—possibly in a decisive—degree on what our universities do, or fail to do, in coming years.

I believe in this decisive role of the university, not because I deprecate the role of our other educational, religious and political institutions; but I believe that the way in which civilization changes over the centuries is largely determined by how men use their heads. The university, as I view it, is the spearhead of man's efforts to make better use of what is in his head. It is at the university that

* Presented June 15th 1954, at the 50th Anniversary celebration of the founding of the engineering experiment stations at the University of Illinois and Iowa State College, Annual Meeting of A.S.E.E., University of Illinois, Urbana, Ill.

men's intellectual abilities are sharpened and are brought to focus on mankind's basic problems. At the university, man's intellectual forces are mobilized for the attack on those great unknowns which lie just beyond the frontiers of knowledge.

It is the role and the task of the university to be eternally dissatisfied—dissatisfied with man's inadequate knowledge; dissatisfied with the ways in which he uses his knowledge. Thus, the chief aim of a university must be, not merely to help individual men to learn more, but to help mankind to know more.

Research Fulfills Primary Aim

And that is about as succinct a way as I know of expressing, not only the goal of a university, but the goal of research—to help mankind to know more. Research, indeed, is the specific mechanism through which the university seeks to fulfill this primary aim—to enlarge man's understanding of the world, his understanding of his fellow men and of himself.

You will note that I have used interchangeably the phrases, "to know more" and "to understand more." I do this without apology—and, in fact, with emphasis. To know and to understand are not quite synonymous. For, though one can normally not understand without knowing, we frequently know things we do not understand. Yet the goal of science must be not merely to acquire knowledge for its own sake, but to secure knowledge as a step toward understanding. A research project collects facts, experimental data, not solely to prepare tables of numbers, but as an aid to finding or perfecting a theory, an interpretation, an understanding of the phenomenon. Furthermore, we must be most exacting in determining how far understanding has been achieved. In the field of science we require that understanding shall be quantitative, not merely qualitative, and that it lead to the ability to *predict*. We require that our theory explain *all* the related facts, not just some of them, that it describe accurately *in advance* all experiments which we perform. We also aim for theories which have simplicity, elegance, beauty. Reaching an understanding of things not only satisfies an intellectual desire, but an emotional or aesthetic one too.

In short, then, if the goal of a university is to help men learn more and to help *man* understand more, then the place and purpose of research becomes obvious. Research is essential to the fulfillment of the university's mission. However, the research undertaken must be devoted solely to achieving that mission—achieving understanding.

Now I think it is unlikely that anyone here will quarrel seriously with what I have just been saying. I would probably do well to drop this discussion right at this point while our minds are still on high minded principles on which we all agree, and let each individual and each institution reach his own conclusions as to how to carry the principles into practice. However, I know that engineers are "practical" people and so I shall go a step further and expose some of my own prejudices on the practical applications of these principles. Here we may tread on delicate ground—but with your permission, I will tread anyway.

What ideas do these general principles suggest in regard to the research program in a school or college of engineering? I suggest that they lead to at least three useful rules.

Maintain Close Tie with Basic Sciences

Rule One: Maintain a close tie with the basic sciences. An engineer, after all, is someone who is putting to practical use today what some scientists discovered yesterday. It is pretty likely that the scientists may have a pretty good grasp of what they discovered and their knowledge and understanding will be useful in developing applications. Still more important, the engineer is interested—or should be—in the new practical applications of tomorrow. These will depend on what the scientist is working on *today*.

Now I know the disdain that many engineers have for physicists. They are such impractical guys. Why don't they work on something useful? I'll return to this question later, but right now I'll only say that if the engineers during the 30's had only absorbed a little more of the impractical work of the nuclear physicists, there wouldn't be so much nonsense in the air today about nuclear power. The sooner the engineers take over this field, the better. The physicists have a bear by the tail and they would like to get rid of it. Fortunately, there are a few good engineers getting into the business. But the rate at which new ones are being trained—adequately trained—is so low that it will be 20 years before the engineers are really ready to take over. In the old days a 20-year gap between the physicist and the engineer was not so bad. But things happen faster now and the transition should take place more quickly. For this reason, the engineer who is attempting to carry on scholarly work or research is missing an opportunity if he does not keep in touch with the physicist, the chemist and even the biologist. Needless to say, he ought to pass on what he learns to his advanced students.

What are the fields of physics today that will be of engineering interest tomorrow? I don't know! No one knows. That's what makes engineering so much harder than physics. The physicist can go gaily on looking for new things in any field that amuses him. The engineer has to guess which new things he will *wish* he knew about five or ten years from now.

However, it isn't really that bad. Fertile and promising fields are reasonably obvious. For example, if the engineer keeps his eye on the fields of nuclear physics, the solid state, low temperature physics and microwave spectroscopy, he will have pretty good insurance for the future. In any case, more collaborative research programs between engineers and physicists would be a fine thing. Similar collaboration could also be productive with chemists, mathematicians, geologists and geophysicists. No individual or department, of course, can cover all these areas. But if each person covers one, then all will be covered.

Stick to Fundamentals

Rule Two is closely related to Rule One. If the goal of university research is understanding, then this research must not only keep in touch with the basic sciences from which it springs, but it must also itself *stick to fundamentals*. It is too often assumed that, since the job of the scientist is to do "basic" or "fundamental" research, therefore the job of the engineer is to avoid this and to invent gadgets. This is, of course, nonsense. The engineer *in a university* has just as much obligation to stick to the fundamentals in his field as the chemist or physicist in his. The university civil engineer is not concerned with designing just another bridge or dam, but with developing new practices, new principles, new materials, new methods of structural design. The mechanical engineer does not simply invent an improved governor for a steam engine; he tries to advance understanding of thermodynamics, of solid and fluid mechanics, of the structure of matter, the nature of vibrations, of fatigue, etc., etc.

The university engineer is thus in an extremely critical position, intermediate between the pure scientist on the one hand and the industrial designer or inventor on the other. To some extent he does the things which the industrialist thinks the scientist ought to do—but which the scientist has lost interest in. The physicist is engrossed in the problems of nuclear forces; who is going to develop the fundamentals of nuclear technology. It's a long step from Fermi's first chain reaction to the first economical power plant—and lots of room in between for fundamental engineering research. The same is true in any field. Isn't this the proper place for university research in engineering?

This leads me to *Rule Three:* Be sure

that the goals of sponsored research and unsponsored research are the same.

Here, of course, I enter a large subject which I cannot possibly take time to explore adequately. But it is worth emphasizing that if the goal of research in a university is *understanding,* then this goal is equally valid regardless of who is paying for the research. It is true that the degree to which a university can advance toward its goal of understanding will depend upon the availability of funds. But no funds should be large enough to purchase a deviation, delay or abandonment of that goal. The university is not a supermarket where a customer should expect to find any article he wants. It is not a job-shop, prepared to turn out a custom-built gadget for each and every comer. A university is not even a bank which likes to handle money just for the sake of handling money. When money diverts effort from proper goals, then the university is literally being robbed—no matter how much "overhead" allowance is attached to the contract. A big budget which is buying things the university has no business selling is a sham—and the real university may be suffocated under the load of padding it is forced to carry around.

Gift Horses Should be Looked in the Mouth

It is high time, for example, that universities ceased the practice of accepting any and all gifts or contracts—just because they appear to come "free." Gift-horses most emphatically *should* be looked in the mouth. I know of a college that once accepted a gift of an enormous collection of stuffed birds. Now it is stuck with the job of taking care of them, and, in order to use them, they hire someone to give a course in ornithology—a course which that college, desperately short of funds to teach history and physics, has no business giving.

I have heard of another institution in which half the electrical engineering department is busily engaged in designing radar antennas—not because they are seeking to understand the radiation of electromagnetic waves, but because an Air Force contract for such gadgeteering was available. The excuse was that they could hire three more engineers that way and these men sometimes helped with the teaching. On the same principle, I suggest that the college lease and operate a five-and-dime store, so that the people who work in it can also, on the side, teach economics, marketing, human relations and business English.

I am just as cognizant as anyone of the problems of financing higher education. I spent four years working on a Commission which studied the subject. We didn't find any easy answers. But I did not become convinced that the problem would be solved by financing things that were *not* higher education.

I must, of course, at this point recognize that, for better or for worse, the modern university has committed itself to carry on activities which do have little relation to higher education. The state universities render a variety of services to the agricultural community which might be more appropriately handled by some sort of farm bureau. And other local services have been assumed in special cases. Most important, the universities have been called upon, and have patriotically and properly responded, to help the national defense in time of emergency. The contributions which universities have collectively made in this area are beyond calculation.

But we should not be led into thinking that designing weapons of war is a normal and proper function of a university as a university. It is an emergency function rendered, in part, because special technical talents are available in universities, and, in part, because certain administrative problems are avoided and because better people are attracted to university operated laboratories. I believe there are sometimes even indirect benefits to the teaching or research program of the institution. If the project—

which is usually "secret"—can be housed and operated far from the campus as a separate establishment, it is possible that no harm will ensue.

But we should not confuse the operation of special facilities or services for the government as a contribution to national defense with the normal educational functions of a university. Take on these extra services, by all means, when it is necessary or desirable or patriotic to do so. But get rid of them too, when possible. And in any case, in times of peace, they must not destroy the major functions of a university for they are important to national defense too.

On the other hand, we must hasten to point out that the normal, proper goals of a university can often be advanced by federal funds under research contracts or grants. I am all in favor of agencies like the National Science Foundation, the Public Health Service and the Office of Naval Research supporting research programs in science and engineering which the universities themselves originate as a desirable part of their programs. This is fine and there should be more funds available for these agencies to use in this way.

All I am saying is that a proper research program in any field should not be abandoned or distorted or harmed by taking on irrelevant work for which funds happen to be available—and then pretending that this irrelevant work strengthens the program which it has damaged or displaced.

I said a few moments ago that understanding should be the goal of research no matter who finances it. Let me now add that when care and firmness and patience are exercised, financing can be found from many sources—private, governmental, industrial, state—to support research which does lead to understanding.

Research and Education

I return now to a matter which has, no doubt, been bothering many of you as I have been talking about research and education. I have used these terms almost interchangeably. I have spoken of research as a part of the function of higher education. I could equally well have spoken of education as a function of research. Some of you may be wondering whether I haven't heard about the conflict between teaching and research. How every faculty member and every institution must decide how many of its hours and of its dollars must go to teaching and how much to research.

The answer is "No—I haven't heard of the conflict." I have heard a lot of argument, but none that convinces me of a real conflict. If the purpose of a university is to advance understanding, then it follows that both the understanding of the student and of the teacher ought to go together. How a man can really teach science or engineering without acquiring a consuming curiosity about the many things that are unknown is beyond me. And how one can get a glimpse of the unknown without an equally consuming desire to tell it to others who will carry it on is also a mystery. An inquiring mind must be the chief possession of university people—and that's the only kind of a mind that can either explore the unknown *or* stimulate students. I think history has shown that with but few exceptions, research laboratories go dead when not stimulated by the continued intrusion of fresh young minds. And teaching establishments also go dead when not infused by the inquiring spirit of scholarship.

And let that be the fourth and final rule that emerges from our look at the goals of research: The student is the best friend a research man ever had—and vice versa!

Vast Public Relations Job is Necessary

In conclusion, I must express dismay at the vast public relations job to be done—with our students and with the general public. Why is it that there has grown up the widespread impression that science and gadgeteering are the same thing? Why is it that so many people—including some in industry and some in government—believe that the universities

are in the business of making and selling gadgets? These same people have often heard that universities need money. So they naturally conclude that by buying a gadget from a university, they kill two birds with one stone—they get the gadget and take credit for helping the university. How can we correct these impressions?

Possibly we have overemphasized the gadgets—including the weapons—that flow from science and technology. Possibly we need to get back to fundamentals in our public relations too. Possibly it's time to tell the world that the main purpose of science is not to produce bombs and guns and radar—or even refrigerators, radios and color TV. Possibly we should come out boldly and unashamedly and tell the truth—the aim of the scientist and engineer is to advance human understanding. We believe in human understanding for its own sake. We believe humans differ from the beasts largely in their ability and their urge to learn, to know, to comprehend. Men climb Mt. Everest, explore the bottom of the sea, sail to the far corners of the earth, explore the atom, the crystal and the stars—all because they are born explorers—because men are always challenged by the unknown.

And what good is understanding? Well, aside from the fact that we are unsatisfied without it—aside from the fact that intellectual achievement possesses beauty and elegance which is good for its own sake—understanding leads to advances in human welfare. It abolishes ignorance and fear. It enables us to replace the muscular efforts of slaves by the energy obtained from burning coal. It enables men to avoid cold and hunger and suffering and disease. Are science and engineering just the tools for man's amusement and for his ultimate destruction? Let us say rather—and more truthfully—that they are his chief tools in his eternal struggle to achieve his highest moral and spiritual ends.

In the News

The Chemstrand Corporation, in production since December, 1953, now is operating as the first wholly integrated nylon manufacturing facility in the United States, Henry H. Bitler, president, announced today.

Pioneering aerodynamics research at airflows well above the supersonic is being carried out in the Guggenheim Aeronautical Laboratory, **California Institute of Technology** (GALCIT), it was reported today. GALCIT scientists are investigating, experimentally and theoretically, how air flows around a body at hypersonic, or faster-than-supersonic, speeds. They are using two hypersonic wind tunnels, one of which has now achieved a speed about eleven times that of sound, or Mach 11. (Mach 5 is arbitrarily taken as the beginning of the hypersonic range.) Alfred C. Ingersoll, assistant professor of civil engineering at the **California Institute of Technology**, has been appointed a Point Four Program specialist in engineering fluid mechanics to serve at the Bengal Engineering College in India, it was announced today.

He has been granted a leave of absence by the Institute Board of Trustees to serve in this capacity. He will aid in establishing a fluid mechanics laboratory for both research and instruction at the College, located at Sibpur, India.

Interim Report of the Committee on Evaluation of Engineering Education*

Objectives of Engineering Education and Their Implementation

Foreword

The ASEE Committee on Evaluation of Engineering Education was appointed in May, 1952, by President S. C. Hollister. The charge to the Committee was to determine the pattern or patterns that engineering education should take to keep pace with the rapid developments in science and technology, and to educate men who will be competent to serve the needs of and provide the leadership for the engineering profession over the next quarter-century.

The Committee on Evaluation began its work in June, 1952, at the Dartmouth meeting of the ASEE. The Education Committee of E. C. P. D. immediately requested the Committee to give consideration to the development of standards that might aid E. C. P. D. in bringing engineering accreditation in consonance with future responsibilities of engineers. The Committee on Evaluation was asked particularly to clarify the curriculum content that differentiates engineering education from that in science or in technology.

In order to enlist the aid of engineering educators throughout the United States in this important undertaking, the Deans of all engineering colleges having accredited curricula were invited to appoint Institutional Committees to conduct their own studies on evaluation of engineering education. A series of questions, based in part on previous evaluation studies as outlined in Appendix A, expressing the broad problems confronting engineering education, was sent to all of these Institutional Committees to form the basis of exploration. The discussion of these questions by the Institutional Committees and the ASEE Committee culminated in the preparation of a series of institutional reports and in the Preliminary Report which was issued in October, 1953.

This Preliminary Report was distributed for critical review to all colleges with accredited engineering curricula. Reports embodying the criticisms which developed were then prepared by the Institutional Committees. The extraordinary response of the institutions in reporting their views resulted in an extended and penetrating analysis that was nation-wide in scope. The recommendations contained in these 122 reports were studied by the main Committee. Many of these recommendations, together with those of the Committee itself, now form the basis of this Interim Report.

The Committee wishes to express its grateful appreciation to all those on the Institutional Committees whose efforts have made this coordinated study possible. It has made free use of the ideas and of the particular phraseology of individual institutional reports without citing specific references. Not all of the recommendations from institutional reports could be incorporated in this Interim Report, but the dominant issues were included. However, the analyses presented in these institutional reports aided the Committee in understanding the nation-wide thought of engineering educators.

Because of the long-range importance of this study, the Committee concluded

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that this report should be submitted as an Interim Report, so that it may be reviewed critically by the Society and further revised in the light of such an appraisal.

In view of the significance of graduate study, the Committee has recommended that a comprehensive investigation of the evaluation of graduate study in engineering be undertaken by ASEE. It is understood that this will be done and for that reason graduate study is not treated as adequately as it otherwise would be in this Report. The evaluation of the influence of humanistic-social studies upon engineering education is presently being conducted by a special committee of ASEE. Hence this subject is treated broadly rather than in detail in this Report.

The Committee wishes to express its appreciation to the Engineering Foundation, the constituent Societies of E. C. P. D. and the General Electric Company for the financial assistance which made this study possible.

Objectives of Engineering Education

The determination of the pattern which engineering education should take in the future must, of necessity, be based upon the obligation of the engineering profession to society, and on the importance of the development of the student as an individual. The obligations of an engineer, as a servant of society, involve the continual maintenance and improvement of man's material environment, within economic bounds, and the substitution of labor-saving devices for human effort. Moreover, he is at all times responsible for the safety of people, and his activity usually has a direct bearing on the welfare of large segments of society. Like the physician, the engineer must work within the current limitations of the state of his art, and decide which of several possibilities provides the best solution to a given problem.

The state of engineering is far from static, for engineering is essentially a creative profession. It has played a dominant role in building American industrial superiority, in developing the principle of mass production, and in giving the American people their high standard of living. The extension of our knowledge of basic science has opened doors to vast new areas of engineering endeavor, and has expanded the foundations underlying many of the existing engineering fields. Some of the newer fields of engineering have been reasonably alert to assimilate new scientific advances into their teaching programs. Throughout the past half century there has been a continuous reappraisal of engineering education, with introduction of new material and substantial shifts of emphasis to keep it responsive to the needs of the profession. The response of engineering educators to the challenging developments of modern science will have a vital influence upon the course of engineering progress in this country.

Any attempt to specify the content of an engineering curriculum must be preceded by the development of a clear understanding of the objectives of such professional education. These objectives are two-fold and are based on the technical and social responsibilities that must be assumed by graduates electing to enter the profession. The entire professional educational process is more inclusive in scope than a four-year engineering curriculum, for it also includes training in high school and post-graduate study in a university or in industry, along with continual self-study and engineering practice before full professional status can be achieved. The first objective, the technical goal of engineering education, is preparation for the performance of the functions of analysis and creative design, or of the functions of construction, production or operation, where a full knowledge of the analysis and design of the structure, machine or process is called for. It also involves mastery of the fundamental scientific principles associated with any branch of engineering,

including a knowledge of their limitations and applications to particular problems, such as the development of materials, machines or structures, as well as the ability to make critical analyses and to organize these into convincing oral or written reports.

The second objective, the broad social goal of engineering education, includes the development of leadership, the inculcation of a deep sense of professional ethics and the general education of the individual. These broad objectives include an understanding of the evolution of society and of the impact of technology on it; an acquaintance with and appreciation for the heritage of other cultural fields; the development of a sense of moral and ethical values consistent with a career as a professional engineer; and finally, the development of a philosophy which will insure a personal satisfaction in the pursuit of a productive life.

Implementation of the Objectives

A number of factors influence the effectiveness of engineering education. Of these, faculty and curriculum have received the greatest emphasis in the nation-wide discussions that have taken place, and they form the central theme of this Report. However, admission requirements, high school-college articulation, existence of adequate facilities, provision for gifted students and the integration of graduate programs will also be considered. All have a bearing on the implementation of any suggested changes in present programs. Nevertheless, thoughtful consideration inevitably leads to the conclusion that the character and quality of the faculty are of controlling importance; therefore, the selection and development of the faculty will be considered first.

The Selection and Development of an Engineering Faculty

The existence of outstanding faculties is far more important to the advancement of engineering education than details of curricula or the magnificence of facilities. The university is a community of scholars and as such requires outstanding teachers to attract outstanding students. To improve and develop courses or curricula, to build up facilities, in short, to attain prestige as an educational institution, all require a faculty of competent teachers and scholars.

A thoroughly competent faculty can be acquired and maintained only if the college administration gives careful and discriminating attention to the important problems of recruitment, selection, training, advancement and termination of employment.

University and College Environment

The academic and professional development of an engineering faculty can proceed only in a favorable environment. Although the environment includes the physical surroundings, the more important part is the intellectual atmosphere; that is, the attitudes and ideas of the people who comprise the university. In such an atmosphere there should first be unity of purpose, the mutual selection of common goals and the collaboration of effort toward their achievement. There must be opportunity and encouragement for intellectual growth and professional development. Teaching loads must be kept at reasonable levels if time for scholarly or creative activities is to be available. The development of a favorable academic atmosphere should be the concern of all faculty members, particularly those in senior administrative posts.

Physical surroundings also contribute to a favorable environment. Facilities may be modest or extensive, as long as they are in harmony with and adequately serve the curricula. Besides adequate class rooms and laboratories, the individual teacher needs appropriate office space, research facilities, technical services, secretarial help, and an adequate library. The extent of the li-

brary, its accessible location and required use are essential elements in any educational process.

The atmosphere of a university is also a significant factor in student progress. Students need a close bond of mutual interest and friendship with members of the faculty. They need objective guidance and encouragement in their intellectual growth, they need sympathetic understanding of their personal problems, but above all, they need the realization that they are being treated as individuals. A faculty which is genuinely concerned with these responsibilities is most likely to create a favorable student environment.

Qualifications of Teachers

The engineering teacher must have a full appreciation of the goals to be achieved. He should realize, first of all, that a course can be taught either as a narrow specialty or as a liberal subject in a professional curriculum, and strive for the latter. Such a liberal course is one in which the teacher inspires his students toward creative endeavor and intellectual development not only while in college but throughout their careers. It is one into which he brings recognition of the importance of intellectual honesty and professional integrity. To achieve these goals he should be endowed with energy, enthusiasm, and a sincere interest in the development of men. To be fully successful he must exercise judgment and tact, and have the ability to meet the minds of his students. He should perform creative work whether it be in teaching, writing, research or professional activities.

The selection of individuals for faculty appointments requires the evaluation of their qualifications. Good teachers have always been personally creative and able to inspire their students to creative endeavor. In the past, they necessarily emphasized the art or practice of engineering. However, during the lifetime of present faculties the art of engineering has come to depend greatly upon the basic science of engineering. It must also be recognized that the universities are better equipped to teach the science underlying professional practice, whereas industry is better adapted to provide experience in practical applications. Within a faculty there should exist a balance of experience in both the science and the art of engineering.

For a relatively young candidate for a faculty position, the strongest evidence usually available to measure probable creative ability in teaching and research is an educational background which includes the doctor's degree. For experienced persons, evidence of the capacity of the individual for creative teaching and research may be gauged by other criteria, and the formal educational background is of less significance.

Young engineering teachers who hold only the bachelor's degree should be employed only in a temporary position that presupposes continuation of education. Lack of such progress should be sufficient reason for termination of such an appointment.

Appropriate industrial experience is important in a well-balanced faculty. This experience may be considered in the selection and advancement of individuals, but it should not be a requirement for faculty members with special educational background or with demonstrated creative ability in research or teaching. Every teacher should become a recognized expert in his field regardless of his background. There is no substitute for knowledge of subject matter far beyond the limitations of that to be taught. However, it is recognized that mastery of subject matter alone will not guarantee good teaching and neither industrial experience nor advanced degrees in themselves are adequate criteria. The minimum essentials for good teaching are the mastery of subject matter and the capacity of the teacher to draw students into active participation in the learning process. Strong individuality is often

characteristic of distinguished teachers, but the capacity to cooperate with colleagues in effectuating the institutional program as a whole is nevertheless of great importance.

This short discussion of the desirable qualifications of a good teacher is amplified in an informal letter from a regional chairman of E. C. P. D. to a college president, which is reproduced in Appendix B.

Recruitment of a Faculty

Of paramount importance to any profession is the personnel of that profession. No time can be spent more profitably than that required for the recruitment and development of competent teachers. Recruitment of a faculty embraces the contacting of persons whose aptitudes, abilities, and personalities are of the desired type; telling them of opportunities, environment, obligations, and limitations of the profession; ascertaining whether their ideals and ambitions are consonant with those of the profession and the school; and finally arranging suitable compensation for employment.

New teachers are often those who have just finished study of a part of the wide field of engineering and science. It is recommended that promising undergraduate and graduate students be sought out and their aptitudes appraised as potential teachers early in their schooling. If a student's interest is aroused in a teaching career, his study may be guided to embrace breadth of view and scholarly attitude. Such a program should help to recruit and develop teachers who will carry the responsibility for improvement of engineering education to meet the needs of the future. Care should be exercised to avoid excessive inbreeding; a heterogeneity of faculty backgrounds is inherent in the very concept of a university.

The effective recruitment and retention of a qualified faculty can be insured by the establishment of a salary scale in colleges of engineering comparable to that earned by outstanding practicing professional engineers, as indicated by the published surveys of national societies. The example of accepted practices in establishing adequate faculty salary scales in the profession of medicine and law is offered as evidence that competitive situations must be met if professional education is not to stagnate.

Development of a Faculty

Even though the environment and salary scale of an engineering college may be such as to attract and retain an outstanding faculty, the newer members of such a group will usually need guidance in the techniques of teaching. Their study of the ASEE Report on the Improvement of Teaching should enhance the effectiveness of their teaching materially. The primary purpose of an engineering college is to provide effective instruction in subject matter through the stimulation and motivation of students, and it is essential that those selected to teach be trained properly for this function. Their own use of and insistence on the use of good English, both oral and written, should be considered as an essential part of their teaching of any subject.

Although experienced teachers will generally perform more effectively than young instructors or graduate assistants, it is possible to achieve excellent results with the latter, provided they are effectively supervised. Furthermore, teaching is a beneficial part of the educational experience even for those who later elect industrial pursuits. Seminars, discussion groups, formal and informal conferences between experienced and inexperienced teachers can all be used effectively for the development and growth of a faculty. Informality in such arranged programs has merit as long as it does not encourage the development of irregularity of participation. Such programs must be varied in form to maintain interest.

It is important that faculty members set an example for their students by their membership in professional and technical societies, attendance and active participation in society meetings, study of current literature, and interest in new developments or research. Such leadership among faculty members is particularly necessary in institutions that are able to provide only limited opportunities for research, for it contributes an important element of vitality to undergraduate teaching. The spirit of leadership that inspires the student to want to lead is of great importance. It can be developed by teachers who are men of stature, judgment, wisdom and tact. The ambition for leadership should involve not only ascendence in a man's technical field, but should include service to society as well.

In engineering teaching, continual contact with the forefront of engineering and scientific progress is essential. Leadership in scientific and engineering progress has frequently stemmed from university research activities. The engineering teacher carries a responsibility to contribute to the advancement of knowledge through engineering research. The university must provide the opportunity in terms of time, facilities and assistance to realize this objective.

It is only when teachers of professional subjects are recognized as experts that they have an opportunity for consulting work. Hence, the privilege of such consultation is not considered to be a major factor in recruitment of young teachers. Consulting practice should be considered as a means of developing and further strengthening an engineering faculty. Close association with engineering work or research in industry should stimulate the teacher and improve his teaching. Consulting is also a source of ideas for research. The limit upon the useful extent of this activity has not been determined. However, the belief is widely accepted that an average of one day per week of the individual's time devoted to consulting activity will reflect to the overall advantage of the institution, provided such consulting is of a high professional character.

Faculty members engaged as principals in consulting work must be registered professional engineers or the range of their practice will be restricted. Some younger staff members should be encouraged to become licensed. This statement should not be interpreted as applying to those faculty members engaged in engineering science instruction, research or similar activities.

Evaluation of a Faculty

Evaluation of the potential of prospective faculty members, and of the achievement of existing staff, ranks with the development of a progressive atmosphere as a most important function of a university administrator. Systematic rather than haphazard methods are essential as a guide for recruitment and for making salary adjustments and promotions. Definite policies on termination of employment for those who do not live up to their expected performance are also necessary for proper development of a strong faculty.

It would be most desirable if this evaluation could be done on a quantitative basis, but the Committee is not aware of any systems which warrant recommendation for general adoption. It suggests that there be more experimentation by individual institutions in the development of quantitative systems of faculty evaluation. Any evaluation system must serve only as a partial guide, since personal judgments must remain the most important factor. The Committee recommends that such quantitative systems as are developed be reported at meetings of the Society and in the Journal. The success of some industrial evaluation systems indicates that there is hope for real progress in this area.

The fact that evaluation of the progress of a faculty member must be based

on judgment involving many factors, indicates that administrators at each level should inform themselves of the viewpoints of their faculties before reaching these judgments, realizing that there are dangers in judgments made by associates of the individual concerned. In particular, the faculty should be as completely informed as is possible concerning the methods used in evaluation.

Evaluation, to be effective, should be as objective as possible, and it should include along with other factors all the items mentioned in the section on the Qualifications of Teachers with emphasis upon:

a. The effectiveness of the individual's teaching based upon knowledge of subject matter, intellectual capacity, quality of judgment, professional and personal stature, and qualities of personal leadership as shown in his ability to inspire students.

b. His productivity in research and other creative areas including new methods of presentation of his subject matter.

c. His activity in professional societies, government and community affairs.

d. The nature and responsibility of consulting services to other areas of the university and to outside organizations.

e. His publications.

f. His professional development as evidenced either by progress in early years toward advanced degrees, or later by his attainments and recognition as a scholar in his field.

It is important that administrators advise members of the staff periodically regarding their standing, particularly those who should be encouraged at an early date to abandon a teaching career. Mere lack of promotion or salary advances should not be assumed as a sufficient method of criticism for individuals who are not developing according to the standards expected.

It is equally important to stimulate the good teacher by verbal or written approbation either for general progress or for special accomplishments. It is essential that those staff members endowed with energy and enthusiasm combined with high technical ability that is applied in a creative manner be compensated to the fullest measure.

An adequate staff either in a departmental faculty responsible for a curriculum or in a major supporting group, will have at least one in every five who has attained professional distinction. Such individuals will (1) be conducting high grade research of an engineering or educational nature, or other creative activity including publishing of a good quality, (2) be engaged in consulting work at a creative level, (3) be exercising leadership in scientific, educational, and professional societies, or preferably (4) be serving in a combination of such activities.

Curricular Content as Related to the Objectives of Engineering Education

Instructional Goals

The ultimate goal of engineering education is the development of able and responsible men fully competent to practice on a professional plane, especially those who will eventually lead the profession to new heights of accomplishment through creative practice or research. The student, not the curriculum, is the primary concern, yet the curriculum has an important influence on education. Before considering curricular components, the instructional goals toward which they are directed should be examined.

The instructional goals of engineering education include helping the student to learn to deal with new situations in terms of fundamental principles, on his own initiative, and with confidence and sound judgment. The goals should include motivation to keep abreast of the new developments in science and technology, and to continue to grow intellectually in

both professional and cultural areas throughout life.

In professional engineering practice the "new situation" often involves social and economic as well as technical elements and these are not entirely separable. Thus the end result is not merely the numerical solution to the technical problem, but is rather a decision based on a value judgment to which the quantitative technical result contributes one important element. In fact, the significant problems involving engineering seldom occur in well-defined form. Hence, the initial stage of thinking is often an intuitive groping to identify specific component problems. Their solution, in turn, requires the application of thoroughly understood fundamental principles and well-ordered analytical thinking in defining the problem, planning its simplification without losing its essential nature, conceiving a method of attack, carrying the study through to a successful conclusion, and checking the results at each stage. This technical solution is then available to guide the broad decision based upon many other values in which the engineer may participate to the extent that his perspective and judgment extend beyond purely technical matters.

Engineering educators must never lose sight of the broad issues with which large engineering problems are always associated, but it must be recognized that the ability to deal with such broad issues comes only with experience and maturity in the years after college. The importance of keeping such economic and social ideas before students by example cannot be overemphasized. Such concepts should be encompassed even though the main effort at the undergraduate level is largely restricted to developing the student facility and power in the scientific and technical aspects of engineering education. In what follows, therefore, these disciplines are emphasized even though they are but a portion, albeit a vital one, of the total education that the successful engineer acquires in college and throughout his subsequent professional career.

The evolution of engineering curricula has been characterized by a continuous process of invasion of new scientific and technological knowledge. Such innovations have necessitated the development of new concepts or shifts to more fundamental and scientific approaches. It seems evident that the frontiers of science and technology are advancing at a more rapid rate now than at any previous time, and that many of today's frontiers will be reduced to significant engineering practice in the years ahead. Furthermore, these newly developed frontiers illuminate the older fields with new concepts and rejuvenate them with increased vitality. It is a responsibility of the engineer to recognize the new developments in science and technology which have significant potentialities in engineering. Moreover, the rate at which new scientific knowledge will be translated into engineering practice depends, in a large measure, upon the engineer's capacity to understand the new science as it develops.

This translation of new scientific developments into engineering practice will be facilitated by emphasizing unity in scientific subject matter. For example, there is a great deal of similarity both in conceptual understanding and in analytical methods among the generalizations of heat flow, mechanics of fluids, electromagnetic fields, and vibration theory. When a student understands these generalizations, he has gained a concept of systematic orderliness of many fields of science and engineering which enables him to approach the solution of problems in widely diverse fields, using the same analytical methods. This unification of methods of analysis can be accomplished to a considerable degree without reaching beyond undergraduate mathematical levels. It can be accomplished to an even greater degree by

utilizing advanced mathematical concepts.

Looking at the subject of instructional goals even more broadly, one must conclude that the engineer should be a well-educated man. He must not only be a competent professional engineer, but also an informed and participating citizen, and a person whose living expresses high cultural values and moral standards. Thus, the competent engineer needs understanding and appreciation in the humanities and in the social sciences quite as much as in his own field of engineering. He needs to be able to deal with economic, human, and social factors of his professional problems. His facility with, and understanding of ideas in the fields of humanities and social sciences not only provides an essential contribution to his professional engineering work, but also contributes to his success as a citizen and to the enrichment and meaning of his life as an individual. Thus, instructional goals include motivating students and providing them with stimulating opportunities to gain understanding and appreciation of our historical and cultural heritage. This requires that the faculties of the humanities and the social sciences regard teaching engineering students as challenging and rewarding, and also that every engineering faculty adopt an appreciative and understanding attitude toward his colleagues in the liberal arts.

It is also clearly recognized that many engineers progress into managerial and top executive positions in industry and government. For such individuals, the foundation should be laid in college for an understanding of human relationships, the principles of economics and government, and other fields upon which the engineering manager can build. This foundation may be built more solidly in humanistic social courses than in highly applied studies in management.

Education for the profession of engineering does not stop with the acquisition of a degree; it must continue throughout life. The most important goal of engineering education is to motivate the student to learn on his own initiative.

Curricular Areas and Content

The preceding discussion of instructional goals clearly indicates that certain curricular areas are obviously basic to undergraduate engineering education. These areas include mathematics, physics and chemistry, the engineering sciences, the application of these to the analysis and synthesis of engineering systems within the major field, technical courses outside the major field, and humanistic-social studies.

In the following paragraphs, the more important components of an engineering curriculum are described briefly, together with a rough indication of the broad curricular content and approximate level that appear to be appropriate to an undergraduate curriculum. These are not intended as a statement of rigid requirements since the Committee recommends widespread experimentation. However, significant departures should be accepted on the basis of clearly stated objectives rather than on the maintenance of a traditional approach.

Mathematics—Casual perusal of professional journals is sufficient to show that all branches of engineering are continually becoming more dependent upon mathematics of an increasingly high level. Although mathematics can never take the place of engineering judgment, such judgment is more and more often guided by mathematical analysis, and such analysis is rapidly expanding the demands it places upon advanced areas of mathematics. At the undergraduate level, competence in the theory and use of simple ordinary differential equations and their application to the solution of physical problems lies close to the boundary of minimum acceptability of mathematics in any satisfactory engineering curriculum. For students whose interest will be centered in research, [illegible]

or the higher phases of analysis and design, or who contemplate subsequent graduate study in engineering, additional mathematics may be both desirable and necessary.

A minimum level of performance in mathematics should be established whether it be obtained in required mathematics or in engineering courses. However, few engineering courses are taught in a manner to make a significant contribution to the student's knowledge of basic mathematics, nor is time available for this purpose. The engineering sciences and subsequent professional subject matter should be developed by making effective use of such mathematical proficiency, and should be taught by staff members competent to do so.

Physics—Too often the physics taught to engineers fails to embody the many revolutionary new concepts that have been developed during the past generation that are today strongly influencing engineering practice. Modern physics, including nuclear and solid state physics, should be a part of undergraduate engineering curricula. The customary duplication between classical physics and the subsequent engineering sciences of mechanics, thermodynamics, and electricity serves a useful purpose only when it is consciously designed to achieve the recognized pedagogical values in repetition. The American Association of Physics Teachers has undertaken to investigate the problem of teaching more advanced physical concepts to engineers. Every effort will be made by the ASEE to cooperate fully in any proposed study of this problem.

Chemistry—Chemistry should include topics in inorganic, organic, and physical branches presented in condensed and general form. The initial study must prepare engineers to enter advanced courses in chemistry and in applications such as properties of materials, metallurgy, fuels and combustion, corrosion and industrial chemical processes. Hence, such subjects as rates and kinetics of chemical change, chemical equilibria, phase diagrams, solutions, electrochemistry, and colloids should be included. As the content of the subject of engineering physics is revised, careful coordination should be effected between modern physics and chemistry. For studies beyond the usual freshman chemistry course, it is felt that other than chemical engineers may need only a speaking acquaintance with organic chemistry but a working knowledge of physical chemistry.

Engineering Sciences—The engineering sciences are here defined as (1) Statics, (2) Dynamics, (3) Strength of Materials, (4) Fluid Mechanics, (5) Thermodynamics, (6) Electrical Circuits, Fields and Electronics, (7) Heat Transfer, (8) Engineering Materials, and (9) Physical Metallurgy. Few existing engineering curricula contain all of these engineering sciences despite wide agreement as to their basic desirability. It is believed that this degree of breadth is highly desirable in practically all engineering curricula, and that the omission of any of them is a significant loss that should be accepted only for compelling reasons. However, there may be some curricula for which applied sciences other than those listed may be desirable. For example, aerodynamics or possibly a life science or an earth science might be more appropriate for some curricula.

In these engineering sciences, full use should be made of the prerequisite mathematics, physics and chemistry, recognizing that repetition is a normal pedagogical necessity, but that it can be most effective only when consciously and purposefully used. Perhaps nowhere else can the qualities of a scholarly engineering faculty be employed so effectively as in the presentation of these engineering sciences with an appropriate mathematical understanding.

Engineering Analysis and Design—Education directed toward the creative and practical phases of economic design, involving analysis, synthesis, develop-

ment, and engineering research is the most distinctive feature of engineering curricula. Such education intrinsically stems from the case method of approach, rather than as an orderly exploration of a given subject matter field. Some experience in this "design" function should be carried in an integrated manner through each semester of the last two years and begun earlier if possible. Among various mechanisms for implementing the case method are: theses, projects, group operations, competition between groups, the use of realistic industrial or unsolved problems, examinations on unfamiliar subject matter, and synthesizing a new device rather than analyses of a given device. These case studies go far beyond, and are quite different from routine repetitive features of practical design, the use of handbooks, or the mere description of structures, equipment or machines, including their construction, operation and maintenance. Such engineering art is learned more effectively from field experience than from college study.

The capacity to design includes more than mere technical competence, and involves a willingness to attack a situation never seen or studied before and for which data are often incomplete, with an acceptance of full responsibility for solving the problem presented on a professional basis.

Non-Departmental Engineering Courses—Such courses as electrical engineering for non-electricals, heat engines for non-mechanicals, etc. should emphasize fundamental ideas and principles and methods, rather than special machines or devices. The most important engineering background of the professional engineer, apart from his major field, lies in the basic sciences and the engineering sciences.

The study of engineering materials, including laboratory testing, is often scattered through several courses and can be coordinated to advantage. Increasingly, forward-looking engineers are searching the recent advances in solid-state theory and chemistry for an entirely new and fundamental scientific approach to their study of the behavior of materials. This field appears to be almost ready for engineering conquest. This development will bear very close watching by engineering educators.

Shop courses and some laboratory courses that emphasize practical work and that tend to displace engineering science in the curriculum should be scrutinized critically in the light of the instructional goals already discussed.

The art of measurement, including analysis of accuracy, precision and errors, and the appreciation of the degree of accuracy economically justified, together with some understanding of statistical methods, are areas worthy of attention in connection with various laboratory courses. The laboratory also has unique value as a place where the applicability of theories may be checked.

Graphical expression is both a form of communication and a means for analysis and synthesis. The extent to which it is successful, for these purposes, is a measure of its professional usefulness. Its value as a skill alone does not justify its inclusion in a curriculum. The emphasis should be on spatial visualization, experience in creative thinking, the ability to convey ideas, especially by free-hand sketching, which is the normal mode of expression in the initial stages of creative work.

Humanistic-Social Studies—The importance of substantial competence in humanistic-social areas should be apparent from the earlier consideration of instructional goals. The educated person has interest and elementary competence in several areas distributed over the broad fields of the humanities, the social sciences and the natural sciences. He has acquaintance with the subject matter of these fields, with the influence that they have on the lives of men, and with the characteristics of thinking that are appropriate to each field, ranging from the highly precise quality of thought in the natural sciences, to the

more tenuous and intangible concepts in art or philosophy. He has developed standards of judgment by which he distinguishes, in each area, that which is good from that which is mediocre. He will, if his total educational experience has been fortunate, have been exposed sufficiently to high quality influences so that those things of lesser quality fail to attract him.

One who has been fortunate to achieve such a sense of values has attained a preparation for living to which all should aspire. Engineers increasingly recognize that technical competence, alone, is insufficient. Understanding beyond technical knowledge is necessary for engineers who take a place of equality or leadership among the community of educated men.

Traditionally, breadth of education has been attempted by exposure of engineering students to courses in social studies and humanities. Such courses are not enough. The atmosphere in an engineering college, although intangible, is of first order of importance. It must be favorable to a liberal education for student success in this direction. One engineering instructor who disparages human values can seriously damage the value of humanistic-social courses in the eyes of those students who look to him as their ideal. Unless, and until engineering faculties appreciate and understand their colleagues in liberal arts, the value of such courses for engineering students will be small. The purpose of such courses is not only to supply tools for solving specific engineering problems, but also to develop a wise citizen and a broadly educated man capable of intellectual appreciation and enjoyment.

The value of personal association of the engineering student with other students and with professors in liberal arts, cannot be overlooked. The exchange of ideas and opinions in open discussion is a source of stimulation toward the acquirement of greater knowledge.

The seeking for immediate usefulness in the social studies and humanities, as tool subjects in engineering, may well lead to failure to achieve the objectives set forth above. Such courses as accounting, industrial psychology, investment economics, comparative costs, or city management may be just as technical as engineering studies. It is outside of such fields that the social-humanistic studies must lead the student. The Committee recommended a much broader study of the effectiveness of the social-humanistic stem of engineering education. Such a study is now under way under ASEE sponsorship.

One aspect of English merits specific comment. Instead of sole dependence upon specified courses, a level of performance should be required in written and oral communication of all engineering students which will develop in them the ability to convey their ideas to others in a clear, logical and interesting manner, using correct and concise language. The attainment of this objective is the joint responsibility of all teachers.

Making Room for New Curricular Material

In this report, several additions to curricula have been recommended without corresponding deletions. More emphasis on fundamental science, more on engineering science, and more on the broad humanistic-social area have been recommended than are contained in most engineering curricula. This does not imply that the engineering student needs to be worked harder. Indeed there is considerable doubt as to whether there is any margin of student time left. Four possibilities for achieving these additional, important objectives are listed below. Each school, no doubt, will wish to choose its own methods, recognizing that those suggested are of varying degrees of practicability to each institution.

These four are as follows:

(1) Raise the prerequisites for entrance. This might entail
   a. More adequate high school preparation.
   b. Higher selectivity.

(2) Increase the efficiency of instruction.
(3) Eliminate some of the material now in the curriculum.
(4) Extend the curriculum to more than four years.

Much has been written about high school preparation. Continuing encouragement should be given to high schools to raise their standards, and to give appropriate training to college-bound students, including engineering students. However, it is doubtful whether engineering educators can realistically entertain serious hopes for substantial gains from this source over any short period of time. One ray of hope lies in the summer programs for high school science teachers that engineering schools, with the cooperation of industry, have been offering.

Although higher selectivity would permit a more rapid rate of academic progress, it would decrease the number of applicants at the very time when national welfare calls for the reduction in the present shortage of engineers.

Increasing the efficiency of instruction is a process more or less continuously under study by many faculties. Newer, simpler ways of looking at complicated phenomena and their analysis evolve continually in the minds of an alert faculty. Profound understanding is often accompanied by the ability to give the simplest and clearest statement. One contribution of our graduate schools to undergraduate education should be a continuous improvement in methods of presentation in undergraduate programs due to better understanding and consequent simplification of subject matter. Such development of better understanding and consequent simplification can, undoubtedly, contribute in an important manner to the solution of the present problem.

Elimination of material now in the curriculum, likewise, is an accepted practice in rapidly growing fields. Two kinds of material can well be looked at with a view toward possible elimination. The first is unduly repetitious material. Conscious repetition, carefully designed as a pedagogical instrument, is necessary, but it detracts seriously from student interest. Much unplanned repetition exists. Other areas due for close scrutiny, with a view toward possible elimination or reduction in time, are those courses having a high vocational or skill content, and those primarily attempting to convey engineering art or practice. The latter belongs in many engineering courses, but its high purpose is to illuminate the engineering science, analysis or design, rather than to teach the art as engineering methodology.

A review of the evolution of engineering curricula over many years shows a trend toward increasing emphasis on the science underlying engineering at the expense of the study of engineering art for its own usefulness. This trend would appear sound for application in the present dilemma.

Thus, the Committee feels that the most promising possibilities of finding time for increased emphasis on fundamental science, engineering science and humanistic-social studies are (1) elimination of some of the present curricular material, and (2) increased efficiency of instruction. Experience would indicate clearly that the faculty that really wants to achieve such ends can and will find a way.

The Committee, after careful consideration, takes no position with regard to the length of the program. It believes, however, that further experimentation is in order in all four of the means suggested for introducing new curricular material.

Providing Opportunities for Gifted Students

Leading engineering educators have long felt that the standardization of engineering curricula in the United States has provided too little opportunity for outstanding students with creative talents to develop these capacities at their greatest possible rate. Most courses are organized

to proceed at a rate that can be followed by the average, and, commonly, by the below-average student. At some place in the undergraduate program there should be an opportunity to break down this lock-step and permit the student full play of his intellectual and creative powers.

The Committee is aware of three possible methods for providing such opportunities. The first is the special curriculum, designed both in content and in method of administration to challenge adequately the exceptional group at the top of a class. The second method is that of permitting the exceptionally able student to elect his program widely, with due precautions against excessive specialization, to carry as heavy an academic load as experience indicates he can handle; and, in general, to let him build out of the courses that may be available a program that is stimulating and challenging to him.

The third method, and the one that philosophically has the greatest appeal, is that of giving the student a great degree of personal freedom to study individually under general supervision and guidance, in whatever way appeals to him as being most effective in his individual case. Combined with this, of course, must be a rather infrequent, but very searching examination, designed to provide an overall test of his accomplishment and to test his level of understanding in a broader and yet more penetrating way than the usual term examination.

The first and second methods, that is, the special curriculum for a gifted group and the individually-elected curriculum, respectively, are in regular practice at various institutions in the country. Any adviser, when given freedom to adjust the curriculum, can adopt the second method when he recognizes among his students one who is capable of benefiting from such a program. While the results of such procedures are extremely difficult to measure with any degree of certainty, the evidence is not unfavorable.

With the third type of program, on the other hand, experience in engineering in this country has not been conspicuously convincing. One difficulty is that, given a large measure of freedom as to place, method and program of study, with only the most general sort of restraints in the form of general examinations at the end of one or two year periods, very few students will absent themselves from rather regular classroom exercises, if these are handled in a reasonably interesting and inspiring manner. They find that the class exercises of such a professor are an exceedingly effective way of acquiring basic, scientific disciplines. Other students, who take seriously the admonition to study independently, often have found the imposition of sufficient self-discipline to assure the same intensity of intellectual effort and actual accomplishment as that achieved by the regular students to be more than they could muster. This has been revealed disconcertingly, on occasion, when such a student has later been faced with the searching doctoral examination in which demonstration of relatively elementary ideas, but at a profound level, has been required. The student who has enjoyed complete freedom under general guidance, somehow has often failed to acquire the degree of exacting mastery of basic principles that is expected.

On the other hand, the brilliant student who becomes the personal protégé of a wise and able professor may attain extraordinary achievement under a free program. This rather rare student is obviously an exception to all rules, and the perceptive and wise faculty member will break all rules in order to allow him to develop his own initiative and ideas. Such students will set their own courses, the faculty member notwithstanding, and they do not constitute the problem being considered here. The adequate social development of such individuals, however, may be a serious problem.

It is, therefore, the rather select group found in the top ten per cent of a good class, but excluding the near genius who is a law unto himself, with whom faculties should be more concerned. There are, of

course, many ways in which the monotony and tedium of the highly organized classroom course for these students can be relieved. All the individual encouragement should be given them which will help stimulate them to something beyond the usual performance. There is a great need for continued experimentation in this area in the search for the solution that apparently is still to be found in this country for this important problem. The European solution, although excellent in its natural setting, has not proved susceptible to direct transplantation to this country. The strongest encouragement should be given to those teachers and administrators who would like to experiment in increasing the responsibility of gifted students for their own education.

Student Selection and Advanced Standing

It is recommended that high school students interested in engineering be encouraged to prepare themselves adequately for engineering work in high school by developing proficiency in the use of English and mathematics, and in gaining an understanding of science, particularly physics and chemistry. A most effective way of so encouraging these students is to make proper adjustment in the work required of them in engineering schools. This may be done by allowing college credit for previous work, or if this is undesirable, by making the credit hours required for graduation flexible and dependent upon the preparation and skills of the entering student. A student should not be required to repeat work in college if he is adequately prepared by work already covered, or by proficiency previously acquired in high school or elsewhere, but instead he should be allowed to proceed into more advanced work. When so excused from taking a specific course on the basis of previously developed proficiency, the student should not be required to substitute other work not demanded of the other students, for this requirement always discourages the student from presenting advanced work for entrance. However, proficiency should be determined by examination and not assumed because of the acquisition of high school units beyond those required normally for admission.

Requirements for admission to an accredited engineering curriculum must of necessity be rather rigorous to insure adequate capability of the student to pursue engineering in an orderly and effective manner. The Committee, therefore, recommends the following minimum requirements for admission:

1. Graduation from an accredited secondary school, or its equivalent in education.
2. Demonstrated capacity for satisfactory achievement in engineering.

It should be recognized that the minimum requirements listed above impose great responsibility upon directors of admission for proper selection of students to engineering colleges, especially when the availability of required courses in the various high schools is taken into consideration. Such students should normally accumulate at least 3 units each of English and mathematics and at least 1 unit of science if they are to make satisfactory progress in engineering schools. Furthermore, unless suitable screening techniques are applied, such students should stand in the upper quarter of the overall integrated group of high school graduates. It is suggested that pursuit of vocational courses should be discouraged as preparation for engineering and that not more than 2 of the 16 units for entrance should be considered from drawing, shop or other vocational work. Additional background in mathematics, science and humanistic-social courses is of far greater benefit to the student.

The Committee also recommends that colleges should:

1. State their requirements for admission clearly.
2. Elect to admit students with deficiencies only when there is strong evidence to indicate probable success in engineering

and always state clearly what these deficiencies are and how they may be removed.

3. Maintain records of criteria used to determine admission.

4. Use such records to improve the screening process.

Students transferring from accredited junior, liberal arts or other engineering colleges should be admitted on a provisional basis, and the final transfer of their credits should be delayed until their subsequent records indicate maintenance of the required grade point average for graduation. A realistic evaluation of credits presented for advanced standing should be made on the basis of course content or proficiency examination rather than on an inflexible basis of equivalent credit hours.

High School—College Articulation

As preparation for engineering education, there is no substitute for scholarly levels of instruction in high school, with adequate emphasis upon developing both interest and reasonable proficiency in mathematics, English, physics and chemistry. The Committee on Evaluation believes that a great deal can be done to improve the scholarly quality of education offered in the high schools. This can best be accomplished by developing close working relationships between engineering colleges and high schools at the local level. Some engineering colleges have developed conferences and educational programs, participated in jointly by high school and college teachers. Several industries have provided financial support for educational programs. These programs can be highly effective in giving high school teachers insight into the nature of science and mathematical preparation which is needed by students who plan to take science or engineering in college.

In order to encourage high school-college articulation, it is recommended that a study be undertaken by ASEE in cooperation with industrial groups and societies representing mathematics and the pure sciences to:

1. Develop specific techniques for identifying, encouraging and developing those high school students who have aptitudes for engineering or science.

2. Develop specific techniques of reaching high school faculties and administrators in order to enlist their cooperation in a constructive program to improve the quality of high school preparation, particularly in mathematics, physics, chemistry and English.

3. Determine, at each university having a college of engineering, how to provide advanced study as a part of high school teacher education that would make such teachers more proficient instructors of the subjects necessary for admission to engineering.

4. Develop specific techniques for presenting these problems and their possible solutions to high school administrators, teachers and the general public.

Graduate Work and Its Relation to Undergraduate Curricula

So far, this report has been devoted essentially to undergraduate engineering curricula. Graduate work has such important implications for engineering and its objectives are so related to undergraduate curricula that this subject must not be neglected in this report. However, a much more extensive evaluation of graduate study is being planned by ASEE. An undergraduate curriculum must serve a two-fold purpose of preparing some men for immediate employment and others for graduate study. This Committee believes that a single curriculum with a reasonable degree of flexibility, as represented by electives, can meet both of these objectives.

In recent years there have been marked increases in the number of graduate students in engineering and in the number of institutions offering graduate study. The rate of technological advance suggests that an even larger fraction of engineering graduates must go on to graduate study in the future. This imposes upon engineering teachers the obligation to

identify and encourage those students who are properly qualified to pursue graduate work. Many small schools have impressive records in preparing and encouraging their students for graduate work.

Schools which lack adequate research facilities or a faculty with sufficient academic preparation to carry on graduate study can still serve a very important function in advancing graduate level education by providing scholarly undergraduate preparation and by encouraging their better students to continue their education after graduation. Graduate students usually benefit by the diversity of faculty contact which they receive when they change schools at the end of their bachelor's degree.

Graduate students may also benefit from some knowledge of practice. However, the temptations to continue in employment have been so great that the advice to seek employment ahead of graduate study has not produced the result intended. The current sponsored research programs of engineering colleges are such as to provide an alternative to the need, that was so widely felt in the past, for graduate students to bring a knowledge of practice into their graduate work.

The current increase in emphasis on graduate work has raised many questions to which engineering schools are seeking an answer. It appears desirable for this Society to undertake a comprehensive study of graduate work in a way quite parallel to that in which the Committee on Evaluation has studied undergraduate engineering curricula. The following questions and problems are suggested for possible study by such a graduate evaluation committee.

1. When, or under what conditions should an engineering school undertake graduate work? Matters of financial support, subsidy available for graduate students, sources of money for research, support for an expanded faculty and even housing for graduate students arise.

2. All graduate work which is more than an additional year of undergraduate study involves substantial additional investment either in faculties or facilities or both. Therefore, it should not be undertaken without appraising the cost.

3. Should graduate work be specialized or fundamental? One sometimes hears that undergraduate study is fundamental while graduate study is specialized. Those most experienced in graduate work in engineering are likely to feel that graduate work is rather a medium both for deepening and broadening the scientific base for engineering. Sometimes subject matter that appears to be rather specialized provides the most effective stimulus for more fundamental study.

4. What are the requirements for a graduate faculty or a faculty competent to offer a high grade graduate program? In many institutions members of a university faculty are authorized by special election or designation to participate in graduate work. The scholarly standards to be met by thoroughly competent graduate teachers are frequently of a different order from those meeting minimum requirements for undergraduate teaching. Salaries that are barely sufficient for holding an undergraduate faculty may be insufficient to attract and hold competent graduate faculty. The important criteria for a graduate faculty as distinguished from an acceptable undergraduate faculty must, therefore, be specified.

5. The demand of industry for engineers with more than baccalaureate education has resulted in extensive part-time programs at the graduate level for industrial employees. Do such programs meet high graduate standards? Under what conditions do they meet such standards? What are the safeguards that must be applied to assure high academic standards? Is part-time study alone sufficient or of such character as to provide degree programs comparable with those involving full time residence study?

6. What are the requirements for degrees? Should the Master's degree require a thesis? What should be the language requirements, if any? What should

be the residence requirement, if any? To what extent would the degree be essentially a certification of ability of the candidate and to what extent a certificate of satisfactory participation in the institution's own intellectual life and activity?

7. At the doctoral level, what are the examination standards? What characterizes a good examination? What should such an examination seek to demonstrate? Who should be examiners? What emphasis should be given to written and oral portions of the examinations? What are good examination techniques?

8. What constitutes a good doctor's thesis? What are the criteria for judging such a thesis? How does one determine whether or not the criteria for measuring the contribution to knowledge have been satisfied? What should be the course requirements for a doctorate, if any?

All of the questions pertaining to doctoral study, and many others can be answered only in terms of many intangible elements that, taken together, represent a high level of scholarship, scientific and engineering perception, and standard of intellectual attainment. As a concluding remark, it may again be emphasized that undertaking graduate work, of which an institution can be proud, involves a substantial reorientation of objectives in an engineering department and additions to faculty and facilities that may represent major elements of cost.

Since this Interim Report deals so briefly with graduate study it is recommended that those interested in this phase of engineering education refer to A Manual of Graduate Study in Engineering, published in 1945 as an ASEE Committee Report (*Journ. Engr. Educa.*, Vol. 35, p. 650) and revised and reissued in 1952 in monograph form.

Evolution of a Common Stem of Engineering Curricula

The great changes that have come about in physics and chemistry over the past thirty years and the equally great advances in engineering practice seem not to have produced an equivalent counterpart in a reorganization of engineering curricula. At a meeting of the Committee on Evaluation of Engineering Education a group of industrial advisors pointed out that the problems in production and manufacturing are now demanding greater and greater scientific background for engineers. As one example, emphasis was placed upon automation of machines as a current problem of the machine designer. The need for such instruction is critical in certain industries, and several of these offer such courses to their personnel. If this is generally true, engineering education may be a decade late in giving emphasis to electronics in the curriculum of mechanical engineering and in teaching applied electronics as a part of machine design.

Unchanging Factors in Curriculum Design

It is relatively easy to look backward and recognize changes, but it is always more difficult to visualize what lies ahead. After facing many questions regarding the future of engineering practice one is likely to conclude that the teaching of practice, as it exists today, will always be of limited use because the graduate is certain to find practice changing year by year. And, as a matter of fact, the engineering art taught in colleges will normally reflect practice that is already, in part, obsolete since the teacher's knowledge of practice becomes rapidly outdated.

But fortunately, some things do not change. Reactions, stresses and deflections will still occur, and they will have to be calculated. Electrical currents and fields will follow unchanging laws. Energy transformation, thermodynamics and heat flow will be as important to the next generation of engineers as to the present one. Solids, fluids and gases will continue to be handled, and their dynamics will have to be understood. The special properties of materials as dependent upon their internal structure will be even more

important to engineers a generation hence. These studies encompass the solid unshifting foundation of engineering science, upon which the engineering curriculum can be built with assurance and conviction.

Attitudes of Engineering Faculties

The Committee on Evaluation of Engineering Education had arrived at this conviction soon after its organization. The problem that then faced the Committee was to think through the implications of the steadily increasing importance of the engineering sciences upon curriculum design and upon faculty, students and employer relations. The questions to be answered were of the following nature. Would faculties believe that much stronger emphasis upon the engineering sciences and the basic sciences produce only research men? Would the employer be pleased with the product or would he feel that students should be able to earn their pay immediately upon graduation without special job training? Could students undertake a more scientific program without excessive failures?

Not knowing the answers to these questions the Committee suggested in its Preliminary Report the concept of bifurcation as a possible means of transition from the present curricula, which are largely of the general-professional category, to the strong professional-scientific curricula that it visualized as being required for an unknown, but in no sense negligible, percentage of future graduates. As defined in the Preliminary Report, the professional-scientific curriculum included increased emphasis upon mathematics and physical science, the nine engineering sciences as previously described, and a sequence of courses in engineering analysis, design, or the study of engineering systems extending over two years.

After the discussion of the Preliminary Report by the Colleges of Engineering a reasonably clear viewpoint was forwarded to the Committee. This viewpoint consisted of three parts: (1) A strong support for higher standards of accreditation for engineering education but not for designation of especially meritorious curricula. (2) A nearly universal institutional reaction that engineering curricula should not be subdivided into two functional stems but a recognition of the usefulness of functional variation at the top. (3) A growing desire for curricula to approach the definition given in the Preliminary Report for professional-scientific curricula which the country seems to accept as being the probable direction for the evolution of engineering education.

Viewpoint of Employers

After receiving this expression of attitudes from the engineering institutions, the Committee determined to learn something of the viewpoint of employers. At a meeting in Atlanta, Georgia, in February, 1954, seven of the largest employers of engineers were invited to advise the Committee on Evaluation. These organizations employ all types of engineers in all functions from research to sales and construction. In fact, most of the organizations represented employ only a small fraction of their engineers in research, development and design. On the average, less than 25 percent of their engineers work in these fields. One company has most of its engineers employed in operation, another in manufacturing and a third has one of the largest construction organizations in the country. Several employ nearly one-half of their engineers in sales. Nevertheless, the industrial representatives present concluded that they would prefer nearly all of their engineers to be trained in professional-scientific curricula as defined above. The industrialists emphasized that their sales, manufacturing and operation or maintenance engineers needed strong scientific backgrounds just as much as the research and development engineers and designers.

They were unwilling to sacrifice courses in engineering science to provide time for the study of technology or administration at the pre-baccalaureate level since they

believe that these can be obtained under company sponsorship whenever needed.

It seems necessary to discuss the obvious criticism that the industrial advisors to the Committee on Evaluation represent only large employers. The criticism is valid, but there seems to be no way to obtain an equivalently valid opinion from small employers. However, there is reason to believe that small employers even more than big industry need versatile engineers since one man in a small company often designs and builds the product and plans its market in competition with big industry.

Abilities of Engineering Students

The Committee on Evaluation has also given consideration to the question of whether a stronger emphasis upon basic science and engineering science would lead to increased failures to complete engineering curricula. Some who have experimented in this direction give assurance that this common assumption is not necessarily true. The best authority to the effect that engineers can handle additional work in basic science and engineering science without undue difficulty lies in the results of national tests. These indicate that, both at the undergraduate and graduate levels, engineering students show the same high level of mental ability as students of the physical sciences. It seems reasonable to conclude, therefore, that the principal groups of engineering students will prove able and interested in completing whatever type of curriculum the profession of engineering considers necessary preparation for its prospective members.

Opportunity for a Common Stem in Scientifically Oriented Curricula

The consideration of curricula cannot proceed wholly on a philosophical or qualitative basis but must eventually be approached quantitatively in semester hours. The Committee on Evaluation, in order to clarify for itself the practicability of its suggestion that curricula of the 4-year type can be designed with an enhanced scientific orientation, has developed for consideration the broad outline of a professional-scientific curriculum. *It intends this skeleton curriculum to be considered as suggestive rather than restrictive. The great need of engineering education at this time is for experimentation with, rather than standardization of, curricula.*

In defining an engineering curriculum the Committee on Evaluation has first indicated the need for mathematics through differential equations; however, another application of calculus such as statistics might fit more effectively into industrial or sanitary engineering. Nevertheless, for many curricula this means at least one additional course in mathematics. The recommendation that physics should be extended through nuclear and solid-state physics may well require more than the usual eight semester hours of sophomore physics even though there may be some saving by elimination of unnecessary duplication with mechanics, thermodynamics and electrical engineering courses. There is a growing belief that a speaking acquaintance with organic chemistry and a working knowledge of physical chemistry is essential to all engineers and that this objective cannot be accomplished within the usual course in freshman chemistry. For most curricula these changes in mathematics, physics and chemistry would probably require a total of at least 6 semester hours of additional study.

The second major factor in the original definition of scientifically oriented engineering curricula included nine engineering sciences in sufficient strength to justify their separate listing; i.e., (1) statics, (2) dynamics, (3) strength of materials, (4) fluid flow, (5) heat flow, (6) thermodynamics, (7) electrical currents, fields and electronics, (8) engineering materials, (9) physical metallurgy. So that some quantitative measure may be available, it is tentatively suggested that each engineering science deserves from 2 to 6 semester hours, the average being about 4 semester hours. Hence, there would need to be a

total of 36 semester hours for the engineering sciences mentioned, including appropriate substitutions of other applied sciences in special curricula.

The third major element in the definition of an engineering curriculum is that it must contain an integrated sequential study. By this is meant that the mathematics and the basic science shall be used proficiently in the courses in engineering science, and that the latter, in turn, shall be used proficiently in engineering analysis, in the study of engineering systems, and in preparation for creative design work. For the scientifically oriented approach it seems desirable that analysis, synthesis and creative design cover four successive semesters at an intensity to be represented by 5 or 6 semester hours per semester.

In addition, to basic science and engineering science, allowance may be made for a minimum three-credit-hour humanistic or social science course each semester for at least seven semesters and also for a small amount of required technology. On this basis the common stem of any scientifically oriented curriculum may be described as follows in four blocks totalling about one hundred semester hours.

The Committee has used the term "common stem" in an attempt to clarify the necessity for a unity of understanding by students in different curricula. There is no reason why such unified understanding can not be achieved by somewhat different paths, through different courses, with different instructors. It will not be achieved, however, if technology is substituted for basic and engineering science or if courses with names from the fields of engineering science are presented merely as a necessary sideline to the objective of teaching current practice.

The Committee's interest in the curricula outlined above is centered in: (1) the indication that the concept of 4-year professional-scientific curricula is practical, (2) the indication that considerably more than the usual "common freshman year" is a normal evolutionary result that may accompany scientific orientation of curricula, (3) the opportunity presented by an "equivalent semester" of elective study for meeting the interest orientation of students and the functional needs of the engineers engaged in research and management as well as in design and construction.

EXPERIMENTAL TIME DISTRIBUTION IN SCIENTIFICALLY ORIENTED ENGINEERING CURRICULA

(1) Humanistic-Social	21 semester hours
(2) Math and Basic Science (about equal in weight)	36 semester hours
(3) Engineering Science	36 semester hours
(4) Required Technology	7 semester hours
TOTAL FOR THE COMMON STEM	100 semester hours
(5) Major Departmental Sequence of Engineering Analysis, Design and Engineering Systems	21 semester hours
(6) Options or Electives in (a) Humanistic-Social, (b) Management, (c) Basic Science, (d) Engineering Science, (e) Research or Thesis, (f) Engineering Analysis and Design, (g) Technology	17 semester hours
TOTAL FOR THE 4-YEAR CURRICULUM	138 semester hours

These numerical figures in semester hours are to be taken only as rough suggestions since there will be many reasons for variations between institutions and among departments of a single institution. *Experimentation is strongly encouraged.*

Curriculum Adjustment to the Individual

The Committee on Evaluation recognizes as do most faculty members that there is need for as much flexibility as possible within the framework of a given curriculum for each student to extend his

own interests. Some choice may exist in the sequence of social-humanistic courses, in the later courses in mathematics and science, and in the departmental sequence of work in engineering analysis and design. However, it is primarily in the elective courses that the student can best extend his interest toward his future professional activity. The objectives of engineering education are best satisfied when each student is given a free choice of options or elective courses, provided that the courses elected contribute to a planned objective.

The question has been raised as to whether additional work in engineering science could be taught by present faculties without special advanced training. This indicates some confusion as to the objective being sought. Actually there can be no really advanced subject matter taught to undergraduate engineers. Therefore, there can be no question as to the potential competency of most members of present faculties to handle courses in the engineering sciences and in engineering analysis, design and engineering systems. It is merely a changed viewpoint that is desirable. Any teacher who recognizes that he can render very limited service to students by emphasizing engineering art or practice will shift his emphasis to a more scientific approach to engineering.

Conclusion

This Interim Report has dealt with the evaluation of engineering education and with the characteristics which differentiate engineering curricula from those in science. In determining desirable levels of mathematics, basic science and engineering science for engineering curricula, the Committee on Evaluation has been concerned with reasonable, obtainable objectives rather than with minimum standards for accreditation. The latter is the province of E. C. P. D. The present report is offered, therefore, as indicative of the direction in which engineering education should evolve.

The Committee sees no barrier other than tradition that would prevent the development of a common stem of the curricula in a given institution that might approach 100 semester hours. It does not, however, take the position that such unity is universally desirable, but points instead to blocks (2) and (3) of the illustrative curriculum which indicate that somewhat more than one-half of the total credit hours might appropriately be used in the basic sciences and engineering sciences with later emphasis upon the proficient use of these subjects in engineering analysis, synthesis and preparation for creative design as the capstone of engineering education.

The Committee further believes that the differences in the interests and the orientation of students and in the functional purposes of engineering education will be served best by elective blocks of courses equivalent in total to about one semester of study. The choice of such electives, however, should be made only in relation to a planned objective. Such elective study can contribute to the development of a stronger humanistic-social background for some engineers and to a stronger scientific background for others, with resultant overall strengthening of the profession of engineering.

Appendix A

Historical Background of Previous Evaluation Studies

Since the organization of the Society in 1893 there have been many studies of engineering curricula which reviewed content of the several programs and gave a distribution of time to the major divisions of the work. Out of the study begun as the Mann Report, published as Carnegie Bulletin No. 11, came the Wickenden Report of 1923–29, the monumental effort of the Society. It was followed by "Aims and Scope of Engineering Curricula" in 1940 and "Engineering Education After the War" in 1944. Dr. D. C. Jackson's "Present Status and Trends of Engineer-

ing Education in the United States" was published in 1939, and its study of curricula may be considered as a supplement to the Wickenden Report.

Since the Wickenden report is so basic and fundamental it may be desirable to quote a few sentences:

"The multiplication of trunk and branch curricula based on technical specialization has gone fully as far as can be justified. Further differentiation in courses for undergraduates is much more likely to proceed on functional lines."

Some colleges did not heed the suggestion that multiplication of curricula had gone far enough, but have continued trunk and branch divisions throughout the last 25 years.

The Wickenden Report also emphasizes the necessity for continuing study after graduation:

"The most serious deficiency in engineering education is not so much in matter taught or matter omitted in college as in allowing the orderly process of education to stop, where it so often does, at graduation."

It is difficult to over-emphasize the necessity of learning how to study and of continuing study throughout a whole professional career.

The 1940 and 1944 reports, referred to above, emphasized the division of each curriculum into two major areas, titled the scientific-technological stem and the humanistic-social stem. These two studies renewed interest in the "general academic subjects" listed by Wickenden. The wording describing the humanistic-social stem used is practically identical in both reports and the time suggested for this area was twenty per cent of the total. The program was to be an integrated sequence running through four years. During the last decade much thought and much study have been given to this phase of engineering education.

Both reports recommend the 4-year undergraduate program as the desirable norm. However, it was recognized that engineering graduates enter into many kinds of activity and that there should be comparable differentiation in the educational programs. In summarizing the 1944 report, Dean H. P. Hammond outlined the needed preparation for widely varying engineering activities as follows:

"In order to provide for the satisfaction of the needs incident to these trends, the (1944) Committee suggests, for consideration, a plan of curricula differentiation in the fourth year, through which three options would be offered within each major professional curriculum: (1) Continuation of the present type of 4-year program essentially as a terminal curriculum, but with modifications advocated by the Committee, for a majority of students. (2) An alternative fourth year emphasizing subjects dealing with the management of construction and production enterprises. (3) A fourth year intended to prepare for additional years of advanced study by strengthening the student's command and extending his knowledge of basic sciences and mathematics, and by introducing him to the methods of advanced study. This fourth year, and the year or years of graduate study to follow, would be planned as a unit rather than as two stages marked by the usual differences of undergraduate and postgraduate programs."

In 1952 the Society conducted a comprehensive study on methods of improving engineering instruction. This report dealt at considerable length with the problem of "how to prepare students to meet new situations with skill, resourcefulness and leadership."

It also treated the collateral problems of "how to instill in the student the desire to continue to learn after graduation, and how to provide a cultural foundation which will encourage him to contribute to his local community and to civic groups as a mature, thinking, human individual.

The principles of learning stressed "the importance of effective participation on the part of the learner; his motivation through the formulation of a goal; the clear definition of task assignments (preferably defined by the student himself); the evaluation of his progress; and his repeated practice in application." This

project was participated in by committees in over 100 engineering colleges of the country.

In 1945 the Graduate Studies Division of the Society prepared a Manual of Graduate Study. This was completely rewritten by a Committee of the Division in 1952. This Manual deals with:

(1) the objectives of graduate study, (2) organization, (3) transitional studies, (4) developing a graduate faculty, (5) admission requirements, (6) degree requirements, (7) major, minor, and research, (8) the thesis, (9) language requirements, (10) mathematics, (11) examinations, (12) undergraduate courses, (13) non-technical studies, (14) evening classes, (15) cooperative programs, (16) sponsored research, (17) industry institutes, (18) foreign students, (19) student guidance, (20) graduate study in engineering.

Appendix B

Letter to a College President by Harold Hazen, Chairman Region 2, ECPD, Education Committee. Reprinted from *Electrical Engineering* . . .

April 2, 1954

"The important quality that we look for in a faculty is evidence of professional stature and competence, including the kind of competence that may take any number of forms or combination of these. In the case of a fellow in his thirties, or even forties, we are interested to see if he has a doctorate, since if he has, it is evidence that he has had sufficient scholarly interest to go on for graduate work and research. But the doctorate of itself is neither necessary nor sufficient evidence of the quality for which we are looking. It is not necessary because there are many young men of first rate ability who have elected not to take graduate work. We usually ask how it is that a man who is interested in education has not taken the rather natural route of graduate work and the resulting advanced degrees, but we are quite willing to be convinced that there are reasons not affecting his qualifications. On the other hand, the man may have the qualifications to earn and actually hold an advanced degree and still not have the personal qualities or indeed the effectiveness in professional work that would qualify him well as a faculty member. Thus while we use the doctoral degree as a quick, rough-and-ready indicator, it is an indicator rather than a measure of the qualities for which we are looking.

"In an older man, whose formal education took place at a time when advanced degrees in engineering, especially at the doctoral level, were comparatively rare, we would have even less basis for insisting upon a doctoral degree. In such a case we nearly always have to look to other criteria as a basis for appraisal.

"In a faculty of several members in a given department we are likely to expect to find from one to several members holding doctor's degrees, if the faculty is really good. However, it is perfectly possible that professional qualifications of the sort I will mention in a moment are sufficient to demonstrate excellence.

"Publication is another indicator of professional stature. Here again, the mere fact that a man has published a number of papers does not in itself have significance. One asks: were the papers good, did they make significant contributions, were they well regarded by competent men in the field, are any of them recent publications? If the publications are in the form of books, we ask, is the book recognized as making a genuine professional contribution either to the field or to the teaching of the field? On the other hand, is it merely a compilation in a different form of material already available in book form to the profession?

"Another indicator is the kind, if any, of professional work upon which the man is currently engaged. Does he have any investigatory activity under way? One important form of such investigatory activity is research. Such research would usually, though not invariably, be carried out in the institution, either with institu-

tional funds or some form of sponsorship from industry or government. If such work is under way, is it basically just testing? Is it puttering in its professional standards, or is it work that really digs into some new area and offers some promise of real contribution to the profession? This work may be applied or of a fundamental character. If applied, it should still have real intellectual challenge, involve imaginative exploration of new ideas, and in general be of such nature that if it is well carried out, it should lead to publication welcomed by the accepted professional journals in the field. Such research is always stimulated and facilitated if the staff member attracts graduate students as co-workers in such a project. Graduate students, however, are not essential. Such a project need not be large. It may, in fact, be quite modest in its physical and fiscal dimensions. The important point is the quality of intellectual effort involved and the professional significance of the investigation.

"The development of specific hardware may or may not represent good research activity in engineering. The test is not whether or not the product is produced in pilot model or other form, but rather the kind of professional effort that is required and the level of professional competence that is demonstrated.

"Another possibly significant kind of professional work is consulting. We ask, is the man doing any consulting work? If he is, we again ask, is it of a routine character or does it involve substantial responsibility? Is it concerned with some new development, or is he merely doing some handbook-arithmetic application of well-known principles in a routine fashion?

"Another indicator, and a very important one, is the kind of teaching that a man is doing. Is he continually revising the subjects that he teaches in response to the impact of new developments? This does not mean, for example, asking in the field of electrical engineering whether he is teaching television or not; rather it means, is he taking into account in his selection of the areas in the fundamental engineering science that he treats, the kinds of principles that one must understand if he is to have a basic understanding of the field of television? A continuing evolution of the teaching of even so elementary and fundamental a subject as electric circuit theory or electric field theory is evidence of a scholarly and active mind that we like to see in a teacher. We are skeptical of the man whose course has not changed very appreciably in the last ten years in the orientation, outlook, and selection of subject matter. Again this most emphatically does not mean that we expect a professor to teach applications. It does mean that we expect his handling of fundamental courses to reflect, in the selection of material, the selection of illustrative problems, and in the associated laboratory work, the needs of the fields that are active today in practice.

"The kind and quality of a man's teaching technique and the effect this has on his students are significant. Here the evidence is often hard to get and necessarily rather intangible. Nevertheless, there are often indicators as to whether the man's class and laboratory teaching is of a character to stimulate the imagination of his students, to develop their initiative, to challenge their abilities, to broaden their outlook, to impose real responsibility on the student. The contrast with this is the teaching that conscientiously but without imagination, ingenuity or contribution of its own, follows the content of some standard textbook. The problems a professor gives to his students are often very revealing of a professor's professional outlook and the kind of influence that he is bringing to bear on his students. The home problem or laboratory exercise designed to pique the student's curiousity or to make him think out something different from what the textbook has shown, is a good indicator.

"The level of penetration of a professor's teaching provide meaningful indicators of his intellectual stature and the

quality of his influence. Here we ask the questions, does his work have a large qualitative content, or does he emphasize more strongly the analytic, the mathematical, the scientific aspects? Does he cover the theory somewhat apologetically and superficially merely to satisfy a conscience before getting to problem work and applications? Does he try to get his students to understand the basic mathematical theory at least at an elementary level? Does he make free use of the calculus, and in the appropriate fields, even elementary differential equations, or does he stick to arithmetic and algebra alone? If he uses calculus, does he really understand it himself and use it with a reasonable degree of rigor? We feel that engineering schools offer an almost unique opportunity for a student to get the underlying theory and science, and that this school time is to a considerable extent wasted if it is devoted to qualitative, descriptive material in lieu of underlying, fundamental theory.

"We, of course, recognize the importance of the mature individual of broad experience and notable wisdom who can convey to his students an important contribution to their character and to their entire outlook on their profession and life. We should not underrate such a person when we actually find him, but neither should we make the mistake of attributing these high qualities to the genial, personable good fellow who has long lost (if he ever had any) his vigor and his technical acuteness. We must insist upon really acute and penetrating intellectual attributes and general technical astuteness of a superior sort to make our professor eligible for the true elder statesman category.

"Leaving teaching and turning again to other areas of activity, another indicator is the degree of participation of the faculty member in his professional society activities. By participation I mean not only attendance but taking an active part in the meetings and activities. The fact of participation itself is not sufficient. One needs to know whether his participation relates to significant ideas and issues, or whether it is shallow and conventional. In what repute is the man held by his professional associates over the country? Is he known to them because of his professional contributions, or is his name unfamiliar?

"Industrial experience can, of course, be an important measure of professional qualification. We need, however, to look at the nature and character of this experience very closely to determine its relevance to engineering teaching. Thus we look primarily not at the number of years, or even the administrative responsibility that a man may have carried, although these are not entirely unpertinent, but rather at evidence of intellectual qualities and activity that we feel are important in a teacher of engineering. Has he been responsible for significant new developments? Is he the sort of person who can be articulate in relating his engineering works to the underlying engineering science clearly and logically? Has his work been such that he has kept his underlying science and engineering science alive and up to date? Is his exposition clear and logical? Many practical engineers who achieve fine results do so by a kind of intuitive sense which, no matter how successful for a practical engineer, falls flat as far as effectiveness in teaching engineering students is concerned.

"Looking now at the overall appraisal, one cannot expect to find a high score for very many of the people on all of the above indicators of professional stature and competence. A good man, however, will score rather well on more than one of the foregoing categories, including one or more outside of teaching. The better the man, the higher his score and the more categories in which he will have a high score. Furthermore, in a good and well-rounded departmental faculty all of these qualities are present though seldom in any single individual.

"One final word regarding the doctorate is perhaps not out of place, especially as the importance of this degree as a qualifi-

cation for faculty appears to be so widely misunderstood. Doctorates are fine in their place, and they have a place, a place of increasing importance in engineering education. But let's neither give them too much weight, nor ignore them completely. Rather let us try by all the measures we know to determine whether this fellow about whom we are talking is one to whom we really wish to expose our engineering students.

"Thus far we have emphasized primarily the qualities of the individual person at which one looks in attempting to appraise a faculty member. A fine faculty, however, consists of much more than a group of individuals and individualists, who would qualify well according to the foregoing criteria. The element of team play and team spirit is almost as important in an engineering faculty as it is on a college football team. Do the various faculty members work together harmoniously and cooperatively? We must not be misled by the dulcet sound of the words 'harmonious' and 'cooperative.' A very important test of these qualities is the ability of these individuals to differ with each other vigorously and earnestly in an intellectual sense, and indeed on problems of a more philosophic character, but to maintain in all this a degree of objectivity and personal goodwill that makes the friendly golf match or wilderness fishing trip together just as characteristic as strongly expressed differences of opinion and judgment. One looks for evidence of fairly achieved compromise in the common core of earlier courses, and expects the curriculum as a whole to have a unity and singleness of purpose that provides strength. At the same time one looks for the tolerance that permits fine ability and special competence to have its head in elective subjects.

"One also looks for evidence of good leadership, leadership that insists upon a sound, well-rounded, forward-looking pattern in the curriculum and program. Sometimes a fairly firm hand is indicated from a dean to assure that enthusiastic individualists take sufficient time and thought in joint and cooperative effort to assure that their program as a whole makes sense, that it points toward worthy and forward-looking objectives, and considers adequately and imaginatively the advancing fronts of the professional field. But through all the activity there should be evident a spirit of goodwill, of willingness for some personal sacrifice in the common good, and a sense of pulling together that nevertheless encourages expression of individual ability and energy."

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

COMMITTEE ON EVALUATION OF ENGINEERING EDUCATION

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M. M. Boring	R. C. Ernst	J. Marin	K. F. Tupper
G. G. Brown	D. F. Gunder	G. Murphy	E. A. Walker
A. B. Bronwell	G. A. Hawkins	M. P. O'Brien	E. Weber
R. S. Burington	H. L. Hazen	R. L. Pigford	H. E. Wessman
J. F. Calvert	P. E. Hemke	J. H. Rushton	W. C. White
A. P. Colburn	S. C. Hollister	T. Saville	C. L. Wilson
C. S. Crouse	J. A. Hrones	R. J. Seeger	W. R. Woolrich
N. W. Dougherty	L. H. Johnson	H. H. Skilling	D. Young

L. E. Grinter, *Chairman* D. H. Pletta, *Secretary*

Report of Committee on Promotion of Ethical Standards*

It is quite gratifying to state to the members of the American Society for Engineering Education that the affairs of the Committee on Promotion of Ethical Standards are in good condition. Indeed, the condition of the committee's affairs is almost too good, as will shortly appear.

A year ago, the committee set for itself certain objectives, with the approval of the officers and the General Council of the Society. One of the most important of these objectives was to urge upon both individual and institutional members of the Society to consider engineering ethics very seriously.

It appeared necessary to undertake this special objective. That the committee would do so was implied by its appointment in the first place. Engineers probably pay less attention to professional ethics than do physicians and lawyers. Occasionally, an older and prominent engineer raises the issue of ethics. But engineers have usually assumed that they are all ethical, and always have been, and that it is a waste of time to think or talk about the matter.

Engineers incline to take an interest in tangible things: Reinforced concrete, jet engines, electronic controls of broaching operations, that sort of thing. Abstractions are repulsive to most of them.

The committee had misgivings at first. If they were to talk to the members of the Society about ethics, would not most of them shrug their shoulders and go about their business?

The committee owes a profound apology to the Society.

The committee published a preliminary statement in the December, 1953, issue of the JOURNAL OF ENGINEERING EDUCATION. The statement was entitled "On Engineering Integrity." The Society's reaction to this statement was a complete and encouraging surprise. It was impossible to handle the letters which came in. Six hundred and seventy-one items of correspondence remain in the files of the committee chairman. These include only letters which may have value later on. All completed correspondence has been destroyed.

Letters Express Approval

The letters expressed approval of the committee's statement, at least in principle. None were critical. A number of members, and other engineers, offered valuable suggestions for projects appropriate to the committee's aims, and of methods for doing the committee's work.

As was remarked a moment ago, the affairs of the committee are in almost too good condition. Heavy correspondence kept the committee from making progress in other phases of its operations. For example, the committee made no progress in its effort to prevail upon officials of the Society's divisions, committees and sections, to introduce discussion of ethics into their programs for the current year. It was quite impossible both to do this, and to take care of mail.

However, ethics items did turn up in several programs, as a result of interest in the topic. The session on Co-operative Engineering Education this evening, includes an item on ethics, and the entire session of the Division on Relations with Industry tomorrow afternoon is devoted

*Presented at the Annual Meeting of ASEE, University of Illinois, June 14, 1954.

to the topic. Discussions of ethics were included, likewise, in the annual meetings this year of the North Midwest and the Illinois-Indiana Sections of the Society, and in the session of the Young Engineering Teachers at the annual meeting of the Michigan Section. There was some negotiation for a speaker on the subject of ethics for the annual meeting of one of the southern or southwestern sections. We hope that these negotiations were successfully concluded.

Members of the committee delivered addresses on engineering ethics before engineering gatherings not associated with this Society.

Depending on circumstances, and the approval of the officers and the General Council, the committee will continue to keep the question of ethics in the minds of engineering educators by whatever measures and devices appear to be most appropriate.

Furthermore, the committee will at least look in the direction of ways and means of actually introducing instruction in ethics into colleges of engineering. It remains to be seen whether such instruction should be formal or informal, either or both.

The committee wishes to express its deep gratitude to officers, Council, and many correspondents for active encouragement and support.

Respectfully submitted,

THE COMMITTEE ON PROMOTION OF ETHICS, ASEE

W. W. BURTON
N. A. CHRISTENSEN
N. W. DOUGHERTY
P. M. FERGUSON
C. J. FREUND, *Chairman*
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R. W. VAN HOUTEN
R. L. PEURIFOY
L. J. RICH
W. M. RYAN
B. M. TAYLOR

College Notes

With establishment of its new Geophysics Laboratory, says Director Joshua L. Soske, the **Stanford School of Mineral Sciences** now is equipped to take a front-rank place among schools training students in geophysical techniques of exploration for oil and mineral deposits. Stanford's recently-completed Henry Salvatori Laboratory of Geophysics was a $60,000 gift of Salvatori and the Western Geophysical Company of Los Angeles, which he heads.

Dr. George H. Lee, professor of mechanics at **Rensselaer Polytechnic Institute** since 1951 and head of the department for a year, has been made Director of Research at the Institute, it is announced by President Livingston W. Houston.

The Place of the Socio-Humanistic Studies in Professional Graduate Instruction*

By W. L. EVERITT

Dean, College of Engineering, University of Illinois

On behalf of the engineers, I want to express my appreciation for the opportunity of this joint discussion with the Council on Graduate Work. We have and will have many problems in common, for the interest and enrollment in graduate engineering programs is increasing.

I note that the Graduate Council devoted much of its attention at the Houston meeting to the "Education of the Whole Man at the Graduate Level." Essentially I have the same subject this afternoon, and the justification for a certain repetition lies in the advantage of the two groups discussing our mutual problems.

Engineering is a profession interested in action and in creativeness. It involves the employment of men as well as materials, and its practitioners are truly happy only when they are directing that employment for the benefit of mankind. From these characteristics stem both certain difficulties that engineering educators meet, and also certain challenges and opportunities that form the staple of my talk today.

The engineering colleges have for some time been concerned with many of these difficulties and challenges. To be specific, engineering education has been in a ferment since the war and much attention has been given to the problems of preparing engineering students for social responsibility as well as for technical competence. The report in 1944 of the Hammond Committee of the American Society of Engineering Education on "Engineering Education after the War," with its recommendation that at least twenty per cent of an engineering curriculum should be devoted to work in the humanities and social sciences, was an important step. However, although there has been much experimentation with the undergraduate four-year curriculum under this formula, there is still dissatisfaction with the results. It might be well to outline some of the pressures which make the solution of our problem so difficult.

Simultaneously with the development of increased interest in the humanities and social studies, technology has itself been expanding in an almost explosive fashion. In spite of increased emphasis on fundamentals and the elimination of most information on the "how" of industry, the amount of technical material necessary in the undergraduate curriculum increases continually.

Increased Interest in Graduate Work

These opposing forces have caused a few schools (though only a few) to increase their programs for the Bachelor's degree to five years. More important for our purposes today, they have also caused an increased interest in graduate work for both the Master's and Doctor's degrees. The increased need for technical training of the type given for advanced degrees is one important reason why engineering is not likely to move in the direction of medical education and require several

*Presented before the Joint Session of the Graduate and Engineering Councils of the Land-Grant Association, Columbus, Ohio, November 11, 1953.

years of liberal arts before the start of the engineering program. There is a further contrast between medicine on the one hand and engineering and physical science on the other. The medical practitioner seems to require a certain amount of maturity to generate confidence in his patients, whereas often the most productive years of creative scientists and engineers are their early ones. Therefore, there is real danger of loss in national creativeness if the training of the engineer is unduly extended and his active career too long postponed. (Remember we may also have to take into account two or more years of military service.)

Currently, there is much discussion of generalization versus specialization in education many times, I fear, without proper definition of terms. What may appear to be specialization in subject matter may in fact introduce generalization in method of attack or problem solving, and develop the ability to coordinate material from many sources. Use of the case method is an example. Ideally, one should proceed from the general to the specific, but unfortunately the mind of man, and particularly of a young man, does not easily move in that direction. A mathematician friend of mine once recommended we should teach algebra in the first grade and arithmetic in high school, because this would give generalizations first and applications second. Just try this on your children and see how far you get. I did. It has been urged by many that the undergraduate curriculum is the place for generalization, and the graduate program the place for specialization. But, frankly, this does not appear practical in engineering, and so while engineering educators are trying to broaden the work for the baccalaureate degree, they should not overlook the advantages of introducing still wider outlooks in the graduate program.

Broadness of intellectual interest requires maturity. Young people tend to concentrate on the interests they consider important. I do not believe this is a special characteristic of the engineer, but perhaps we notice it most among this group because of the intensity of their interest in their profession as undergraduates. This intensity is an asset as well as a liability. We find the engineering underclassman willing to work hard on scientific subjects, and we take advantage of this. If he is not so willing to work we weed him out. But the more intense his interest in science, the harder it is to excite him in the other fields of man's endeavor, because he does not as yet see their relation to his own needs or future life. Conversely it is probably also hard to interest the adolescent musician in science or the budding social worker in art. Being a man interested in action, the engineer is apt to ask how a given effort will contribute ultimately to his own actions.

Fortunately, as the engineer matures, his interests expand. For example, he may first see the usefulness of public speaking or a knowledge of the law. Furthermore, the wider the interests of his most admired professors, the more rapidly this broadening interest will expand. Therefore, any program for development of social interest requires the active support and participation of the engineering professors. President Hancher of Iowa, in his brilliant address entitled "Liberal Education in Professional Curricula" † before the general session of the Land-Grant Association, emphasized that one of the most important ways of introducing a broader culture is by incorporating in our technical courses reference to the relation of the subject matter to man's progress in economic and social development.

Proper Motivation

Proper motivation is an essential in education, particularly when only a limited time can be given to a certain area. Courses, required or elective, which produce in a student the feeling, "Thank God that is finished, I have gotten over a hurdle, I hope I never meet it again,"

† Published in the JOURNAL OF ENGINEERING EDUCATION, March, 1954.

have indeed failed their purpose. Social-humanistic courses in the engineering curriculum are intended to be an introduction to a lifetime of interest—not an end in themselves. It is for this reason that engineering educators have agreed almost universally that, given a certain amount of time available, social-humanistic studies should be introduced into the curriculum as a sequence running parallel with the technical courses rather than as a group of basic studies to be completed before the engineering program is started.

But this recognition of the need for maturity to develop a true interest in a broader culture for the engineer has generally had little impact on our graduate programs. We should recognize that while penetration into the unknown requires technical concentration, these are also the years when cultural interests are ripe for expansion.

This is not a problem unique to engineering; we have it in common with other fields such as agriculture and commerce where professional material is given in the undergraduate program and further graduate training is necessary for the leaders.

I wish to urge, as several others have before me, that graduate schools should give more attention to the development of a social-humanistic stem for their technical students. It is believed that this requires positive steps and programs rather than mere permission to use such areas as minors. Furthermore, it is in our graduate schools that we are developing the engineering teachers of the future. If, as President Hancher proposes, the cultural development of the four-year student is primarily influenced by a cultured faculty, then there is a special need for greater broadness in the education of our graduate students.

As one of the necessary steps, a limited number of specially designed courses should be developed which require no prerequisites in the particular area, but which do make use of the maturity of the graduate student. Such non-prerequisite courses have been developed in several schools of Business Administration, notably Harvard. Courses of this type might advantageously cut across departmental boundaries. Only a limited number would be needed to initiate such a program, but professors with enthusiasm and high ability are essential for their success. Master's candidates should be encouraged to elect such courses as minors. I personally would hesitate to make them required until their success is proven, and then compulsion should not be necessary.

It is also suggested that programs involving projects in social science might well be developed by individual engineering graduate students. Such a student might study the impact on a community of a new industry, the effect of a change in labor relations, a program of community planning, etc., perhaps tying it up with his own engineering interest. This should be associated with a program of reading guided by an expert in the social sciences.

It is often claimed that intelligent men will broaden their horizons on their own initiative by reading. As an alternative to specific social-humanistic courses, a graduate engineer might be encouraged to engage in such a program of self education. However, to make this effective it would almost surely be necessary to supplement the reading by some planned seminars and to give appropriate credit. Achievement in this area might well be tested by a general examination at the end of the second year of graduate study. We have long accepted a variety of methods of preparing for the language examination for the Doctorate. The candidate may take a course, engage a tutor, travel abroad, or study by himself, provided only that he ultimately passes an examination.

Incentives Necessary

Incentives to the student are undoubtedly necessary for the development of such a program. Our students already feel the requirements for the Ph.D. degree are about all that can be borne. However, many engineering students

would welcome an opportunity to prepare for and take an examination in a broad social area in place of one of the presently required language examinations. This is treading on sacred ground, but the necessity of two languages as *tools* is repeatedly questioned. I suggest that the advantages of this program would justify such a substitution. I doubt if we could make a social-humanistic program for the Doctor's degree effective without such a positive incentive. The intellectual level of attainment required for the substitution of an examination in the social sciences or humanities should and could easily be above that required for the language examination.

It is undoubtedly true that any development of such a program will depend greatly upon the support of the faculty advisers to the graduate students—they must be educated first. We cannot expect that legislation alone, academic or otherwise, will produce revolutionary results. Unless there is a coordinated effort by both the graduate school and at least a few of the faculty, nothing will be accomplished. But I do believe that here is an important area for educational development, at present an almost virgin territory, where real effort would bring rich rewards—both immediate benefits and important contributions to the engineering education of the future.

Sections and Branches

The Annual Meeting of the **Allegheny Section** was held at the University of Pittsburgh on April 30 and May 1, 1954. A short business meeting was held on April 30, new officers were elected, and a report on Regional Activities was presented by B. R. Teare, Vice President of ASEE. The following speeches were presented: "The Professional Union—A Contradiction" by Clarence T. Shoch, and "Management Alignment" by William Whigham.

The principal speaker at the Annual Banquet was W. R. Woolrich.

The May 1 session was a general meeting held under the direction of D. G. Schindler, University of Pittsburgh. C. L. Sonnenschein, Young Engineering Teachers Committee, gave a brief report on the work of that committee.

The meetings were attended by 70 members and guests; the banquet was attended by 105 members, guests and their wives.

The **National Capital Area Section** held its Annual Meeting on May 8, 1954, at the Catholic University of America. Bishop Bryan J. McEntegart, Rector of the University, Titular Bishop of Aradi, welcomed the members. After a brief business session, Mr. Henry H. Armsby made a complete report of the Council's activities and submitted a written copy to the Secretary.

Speakers included Mr. R. H. Buescher and Mr. E. K. Von Fange, both of General Electric's Creative Engineering Program. Mr. Von Fange spoke on "Creativeness in an Engineering Program." This was followed by a "brainstorm" session during which about fifty ideas on bringing creativity into an engineering educational program through specific courses were presented by the audience.

Professor J. L. Artley presided at the afternoon session. The winners of the Y. E. T. Prize Paper Competition were introduced. First place—R. M. Adams; Second place—a tie between A. Lawrence Guess and Haaren A. Miklofsky. Professor Adams read his paper entitled "Value Concepts of Engineering Education."

The Resolutions Committee presented its report, and the Nominating Committee presented their slate which was unanimously adopted.

Improving the Teaching of Engineering*

By J. F. DOWNIE SMITH

Dean of Engineering, Iowa State College

Introduction

Several books and pamphlets have been written on the proper planning and organization by the teacher for lecture, recitation, or laboratory instruction, and there is little point to duplication of such writings. This article is directed towards the philosophy involved in the teaching of engineering subjects.

Art to Science

Of the many branches of engineering, at least one (electrical engineering) started out as a science and has continued as a science. Many of the others, however, have slowly evolved from an art towards a science, some having progressed farther than others. The faculties in the field of architecture and architectural engineering have a quite different approach to instruction than some other engineering faculties.

Analysis vs. Synthesis

What has been the effect of this general trend on engineering education? The effect, on the whole, has been good. Engineers today are trained much better than they were 10, 15, or 20 years ago, and there is no comparison at all between what is being handled in college today and what was considered satisfactory 50 years ago. But there is one important major defect in this training, and which should be considered seriously by all teachers of engineering, regardless of the branch they follow. Over the years we have developed in our engineering schools the philosophy that we should teach the student to analyze engineering problems; whereas a large part of his activities in industry will not only be to break down a problem and analyze the individual parts, but to build something from the individual parts. In other words, we must train not only for analysis but for synthesis. This can be illustrated very well in the field of machine design. Where colleges have teachers of machine design who are capable of original design themselves they are extremely fortunate, and the effect on the students must be stimulating. The typical machine design course actually is generally an analysis of machine elements, so that the student who graduates after training in machine design is a man who can take a machine which has been designed by someone else, analyze the various component parts, can find out from his analysis whether the parts are big enough, should be re-designed, should be strengthened, and would work under the conditions mentioned. But he is not trained how to design a machine. This fact has long been evident in industry, and perhaps is one of the most glaring defects in engineering education today. In some industries, indeed, there is a sharp line of demarcation between the engineer who is a trained analyst, and the designer, who is a trained synthesizer. In general, the analysts are college graduates, and in mechanical engineering the designers are frequently, and perhaps even generally, *not* college men, but who have been trained through apprenticeship to other designers in the creation of new machines. The two types are just as separate as they can be. What a tremendous boon it would be to the mechanical industries if they had the combination in one man.

*Based upon talks given at the University of Missouri, February 1, 1954, and Missouri School of Mines, February 2, 1954.

In electrical engineering, however, it is not that way; and most of the designers in electrical machinery and in electrical communications equipment *are* college graduates, who have this ability not only to analyze but to synthesize. Is this traceable to the way the subjects are taught? Or is it traceable, at least to some extent, to the somewhat different philosophy of instruction?

During World War II, an analysis was made of the inventions proposed by people in this country with regard to winning the war. It was a little shocking to find that the correlation between higher education and inventiveness was negative. Is it possible that some of the educational processes which we have actually tend to stifle the inventiveness of the young men? Unfortunately, this is the author's personal opinion. The stifling is partly traceable to the tremendous increase in complexity in the engineering curricula. All engineering educators, perhaps quite naturally, feel that their own particular sphere of interest is extremely important to the student, and thus curricula become so crowded that the student has little time to think for himself. One of the prime problems confronting the engineering teaching profession today is how to eliminate some of the material in the engineering curricula and give the student a chance to think.

Development of Creativity

But there are other ways of doing this with perhaps less chance for major upheaval in the college world; and several institutions are taking suitable steps. For example, a course in design is being conducted at Massachusetts Institute of Technology in which the students are expected to design machines or objects which clearly could not be designed on the basis of copying from previous reports. There is a marked stimulation to the students, who like working on something new.

At Iowa State College machine design students are given considerable latitude, and often choose their own problems. For example, one of those proposed by a student was a machine for dispensing handkerchiefs. All one had to do was insert a quarter, pull a lever, and out would come a handkerchief, wrapped. The machine was patented and is in production. The stimulation to the student was great—so much so that he switched his emphasis from the analytical to the synthetic, and has made a very creditable record as a designer in industry.

Similar experiences were encountered at other colleges where competent designers were available. When Professor Baldwin was at Pennsylvania State College one of his students (a married veteran) came to class late one day and made the excuse that the bottle warmer he needed to heat the milk for his baby didn't work satisfactorily and kept him late. Professor Baldwin asked the student why he didn't design his own bottle warmer, which he did. It was patented, and is now in production.

Why are these isolated cases being brought to your attention? Because a considerable change in philosophy in the teaching of many engineering subjects could be very fruitful. We should not be in the position of stifling the drive and ambition of the young man who comes to college full of energy and enthusiasm. We should encourage it. The architectural schools have been doing it satisfactorily for years. New problems are assigned to the students periodically, and, in general, none has been assigned to any class in previous years. The students sometimes operate individually and sometimes in small groups. But regardless of the size of the unit each proposal is different from the proposals made by everybody else.

Project Method

The architects pride themselves on the fact that they are original. Originality *can* be fostered in college, at least to some extent. Now the architect does this by a project method of instruction, which is quite different from that in most other curricula in engineering, although partly used by some. Most teachers of engineer-

ing would say that this system would not be completely acceptable to them. It could easily be overdone. But a great deal can be achieved by injecting the project method, in small doses, in the teaching of a few of our engineering courses. To illustrate, Professor E. P. Neumann, who teaches thermodynamics at the Massachusetts Institute of Technology, divided his class into two groups. The one section kept on with the regular instruction as it had been outlined, but the second section was told not to attend classes for awhile: they were given, instead, the problem of air conditioning a jet aircraft. Of course, in the process of air conditioning they had to learn the fundamentals of psychrometry and air conditioning, something about heat transfer and refrigeration, the fundamental thermodynamic properties of refrigerant fluids, but they also had to learn something about physiological aspects. What can a man stand? What conditions does he need for comfort? The interesting thing is that these students, who were picked at random from the class, were given the same examinations at the end of the semester as the students who were taking the regular instruction, and there was no appreciable difference in the results of the examinations. But there was a difference in the attitude towards thermodynamics. In addition, because of the necessity to discuss their problems with people of various professional backgrounds it was a broadening experience. Such items, of course, are not limited to mechanical engineering. The electrical engineering students at the same school were treated similarly, and a group of seniors was assigned the task of designing and promoting, commercially, a gas-discharge flashlight for amateur photographers.[1]

Similar approaches have been tried elsewhere, and the logical conclusion seems to be that one of the most effective ways of improving the teaching of engineering is to try to stimulate the students so that he will do his own thinking in *new* problems. We all realize that there are limitations which must be imposed on how far this idea can be carried. In the use of the project method some of the extensive coverage of engineering knowledge *may* be sacrificed, although this has still to be proved. In the limited attempts made so far in various colleges there is no evidence of *any* loss of coverage for senior design classes. But we are constantly reminded of a wise saying, attributed to Professor Rule of M.I.T., "Some teachers try to cover a subject. Actually they should try to uncover a little of it."

Society of Fellows at Cambridge University

Educators have been aware of this general problem for centuries. One solution is the Society of Fellows at Trinity College of Cambridge University in England. This Society of Fellows is an organization which might well be studied seriously by our educators. Trinity is the largest and most famous college of Cambridge University. Its citizens are some seventy fellows, carefully chosen, when young, largely on the basis of their original treatment of a subject in the field of their interest. They are also examined on general knowledge.

To quote from the report:[2] "These examinations are quite different from the examinations of the American university. They are the same for every candidate, regardless of the subject in which he is working, whether mathematics, or philology, or medical science. The questions are always very general, and the candidate is required to write essays on a number of topics chosen freely by him from a long list. For such examinations cramming is impossible. As to substance, wide reading for several years is the only effective preparation. The competition is

[1] See Gordon S. Brown, JOURNAL OF ENGINEERING EDUCATION, December 1952.

[2] George C. Homans and Orville T. Bailey, in the "American Scientist," 1949, pp. 91–106.

not designed to find someone who can fill a particular position. Trinity wants a man, not a peg."

Former President Lowell of Harvard University was very much impressed by the achievement of Trinity College, and, during an inquiry in 1926 into its effectiveness he was given the following statement: "One-half of the British Nobel Prize winners, one-fifth of the several members of the Order of Merit, and four of the five Foulerton research professors of the Royal Society have been fellows of Trinity College, Cambridge. At present, every officer of the Royal Society is a Trinity man. Other honors and distinctions, in almost equal profusion, have, during the past one-half century, fallen to the lot of the fellows and former students of the college of Bacon and Newton, of Dryden, Byron, and Tennyson, of Macauley and Thackeray, of Clerk Maxwell and Rayleigh." [2]

There are other plans of this general nature. All Souls College in Oxford is now nothing but fellows. No strings are attached. A fellow is set free to do his own work in his own way. There is no link with an undergraduate body.

There is a somewhat similar institution in Paris, the Fondation Thiers, where young men, chosen for their promise, are set apart to live in one house, freed from anxieties about their livelihood.

Harvard has also started a Society of Fellows. While the objectives are, in many ways, the same as those of Trinity, it is still too young to determine its effectiveness. There are certain features about the Society of Fellows at Harvard which make it perhaps unique in an educational institution. "A junior fellow is *not allowed* to be a candidate for a degree. The founders of the Society had in mind, particularly, the degree of Doctor of Philosophy. They felt that a Ph.D. degree, with its high but rigid standards and its thorough but routine apprenticeship, provided a good training for many scholars; but that its atmosphere was not always best for the man who was capable of doing individual research and had an idea of his own that he wanted to follow out to the end. Some of the fellows had doctors' degrees when they were elected to the Society. Others have considered it wise to get degrees after leaving the Society. The fact remains that, with or without a degree, fellows have been able to get jobs and good ones." [2]

Such a Society of Fellows, of course, is an ideal situation, and in the typical college or university in this country, and in particular in state universities, the cost of operating such a society would ordinarily be prohibitive. In addition, administrators tend to put more emphasis on academic degrees than is really warranted by the facts.

Motivation

Generally, in order to stimulate creativeness, there has to be motivation, and this can exist at almost any age. For example, the incentive to the invention of the eccentrically operated slide valve for the Newcomen engine was the desire on the part of a 10-year old Scottish boy to play marbles with his friends, and he thus developed an off-center wheel, two pulleys, and a piece of rope to reverse the engine without his help.

Much of this motivation already exists in college students, but insisting that each student go through a fixed and rigorous course of study could readily deaden the motivation, whereas it should be encouraged.

Mass Production

One of the principal objectives of higher education is to stimulate the student so that his mind is capable of contributing something new, as well as handling those problems which come up every day. Our training in college is not always conducive to the promotion of scholarship or creativeness. Professor William E. Hocking describes [3] some of the training in European universities and how it differs, to some extent, from what we do here. He stated as follows: "Years ago, Professor Levy-Bruhl spent some time at

[3] *Higher Education*, January 15, 1950.

Harvard University. On one occasion he remarked to me on the number of hours of lecturing time spent by the American college teacher. 'In America,' he said, 'you respect scholarship, but you do not respect the conditions of scholarship. At home in Paris I gave two lectures per week. The rest of my time is for my own study and writing.

'The American situation results, in part, from the immense educational undertaking, of which we have spoken; in part, from the system of bookkeeping necessary to give an honest value to diplomas delivered in thousands; in part, from immaturity of purpose in the American college boy. Unless the student has his own mental initiative, and, therefore, his own questions, the labor of the instructor is first to raise the appropriate question in his mind, and then to supply the answer.

'The end is mental power, and power cannot be tested by the ability of any student to answer *my* questions. It must be tested by the ability of the student to frame his own questions and to devise his own way to an answer. I submit to the American method; but its very laboriousness for the teaching staff is in grave danger of defeating its own end—the development of power in the student.'"

The Social Humanities

We are all aware of the continuing pressure from all directions to increase the content in the engineering curricula. Thus there has been pressure to put into effect in engineering a five-year curriculum to permit absorption of this increased knowledge. This, at the moment, does not seem to be the proper solution.

There has also been a tendency to increase the social humanity subjects in engineering. That these subjects are important, when properly taught and assimilated, is unquestioned. But we can't keep putting into engineering curricula more and more subjects without taking something out. There has been constant, understandable, opposition from each of the various disciplines when it is proposed that that discipline be reduced or eliminated.

A possible solution has been presented by President Virgil Hancher of the University of Iowa.[4] Many others in the past have stated somewhat similar views, but none quite so clearly as the statement by Dr. Hancher. In summary, he stated that the two principal contributions to higher education in America were the land-grant college and the four-year liberal arts program. This four-year liberal arts program does not exist anywhere else in the world, according to Hancher, except where it has been established by Americans or other persons having before them the model of the college of liberal arts as it developed in this country. For example, if a man wants to study law in Great Britain, his liberal arts training is combined with the law in such a way that he gets both; and, according to Hancher, "The study of law (at Oxford University) was as certain a means of becoming liberally educated as the pursuit of any academic major in any college of liberal arts in this country, either at that time or since." The same thing is true of medicine, and of engineering. It is probably true that the average student in a European university is somewhat more mature mentally than the average American college student, and there is unquestionably a more rigorous training in high schools in Europe than in many American communities. For example, in a major technical college in Scotland, there is no instruction in liberal arts subjects as such. Of course, before going to college the students would have to pass examinations in many subjects including English, one, two or three foreign languages, mathematics, history, and so on. Thus, it might be assumed that at least some of the social-humanity subjects had been taught adequately in high school. But there is a distinct possibility that we may be doing a disservice in this country by classifying the liberal arts as a disci-

[4] Hancher, Virgil, JOURNAL OF ENGINEERING EDUCATION, March 1954.

pline entirely separate from engineering. Is there any reason, for example, why a teacher of engineering could not inject the liberal arts into his instruction? If an engineer is getting into the design of bridges, couldn't a history of bridge builders in the past be brought in at the same time, showing the developments of men like Roebling, and the influence they had on civilization. While teaching thermodynamics, would it not be perfectly feasible to bring in a little of the romance which is attached to the steam engine, the turbine, the gas turbine, jet propulsion, space flight, and so on, showing the effect of each development on the profession and on the community. It might be argued, justifiably, that this would reduce the technical content of the course, although this would have to be proved.

But even if it were true, are we not trying to help the student cover too much with the time at his disposal? We ordinarily give the student in engineering such a concentrated dose of technical facts that a leavening of this type might well be desirable. It is quite possible that by proper cooperation with the other faculties in the social humanities, a valuable exchange of information might be obtained. Many educators are opposed to having engineers take a course in a liberal arts subject which is really a prerequisite for a major in that field. Ordinarily the engineer does not get out of it what the engineering profession thinks he should. But we *could* inject certain of the humanities into our engineering instruction. It may be objected, rightly, that our engineering faculties are not competent to teach engineering subjects with suitable doses of the social humanities injected. This is probably true; but is it not possible that the engineer could learn? This, then, might be a place for our mature graduates to study some of the social-humanities intensively themselves, and bring those studies to bear in the broadening of the teaching of the engineer.

One might draw the conclusion from some statements in the literature that nothing less than the direct teaching of cultural subjects, without vocational purpose, could save us. But other thinkers have spoken rather differently.

A. N. Whitehead wrote:[5] "The antithesis between a technical and a liberal education is fallacious. There can be no adequate technical education which is not liberal, and no liberal education which is not technical."

Sir Fred Clarke wrote:[6] "An adequate philosophy will transcend the popular distinction between the cultural and the vocational."

Engineers must be made aware of the social implications of their work, and this may be partly accomplished by the incorporation in our engineering instruction of the broad liberal approach.

Regional Training of Engineers

It is also clear that in some fields we cannot improve the caliber of instruction in engineering because of the limited number of students involved in a department. It is always difficult for the administration to justify spending large sums of money for laboratory equipment for a relatively few students. It is possible, then, that in the near future we must consider more regional training in certain fields where instructional costs are, at the moment, high. This has been started in the south and apparently operates satisfactorily in such fields as veterinary medicine. There is no reason why this might not also be developed in engineering. It certainly would be one way of improving the teaching in certain curricula. The political implications must be faced sooner or later.

Summary

In summary, it is the opinion of the author that some improvements in the teaching of engineering subjects may be achieved by study, and the application of good teaching methods, as explained in

[5] A. N. Whitehead, "The Aims of Education and Other Essays."

[6] Sir Fred Clarke, "Freedom in the Educative Society."

many texts now available. But a major improvement might be obtained by changing the philosophy and analysis of engineering teaching, even if this change in viewpoint might apply to a limited number of courses in each curriculum. In particular, we must pay more attention to the development of the potentially creative engineers. In addition, we should consider possible improvements by pooling the efforts of many of our universities and colleges.

In the News

EJC Convocation on Nuclear Engineering

To meet "the pressing problems of nuclear engineering and the related sciences," with particular interest in "industrial usefulness," **Engineers Joint Council**, composed of major American engineering societies with a total membership of 170,000, today announced initial steps toward an organized program of confronting these problems "authoritatively by a group of leading engineers."

In making the announcement, Thorndike Saville, President of the Council and Dean of Engineering at New York University, commented that "action by this powerful engineering group is further evidence that nuclear energy is well on the way to having important peace time industrial usefulness." The likelihood that physicists, chemists and others will be invited to join the engineers, as their organization develops, was indicated by Warren L. McCabe, Administrative Dean at Brooklyn Polytechnic Institute, Chairman of Engineers Joint Council Committee on Recognition of Specialities in Engineering. The movement is expected to bring together most of the country's eminent participants in industrial nuclear development.

Although organization of the new group is in its initial stages, a national convocation in 1955 is contemplated for discussion of the subject of nuclear development for industrial use.

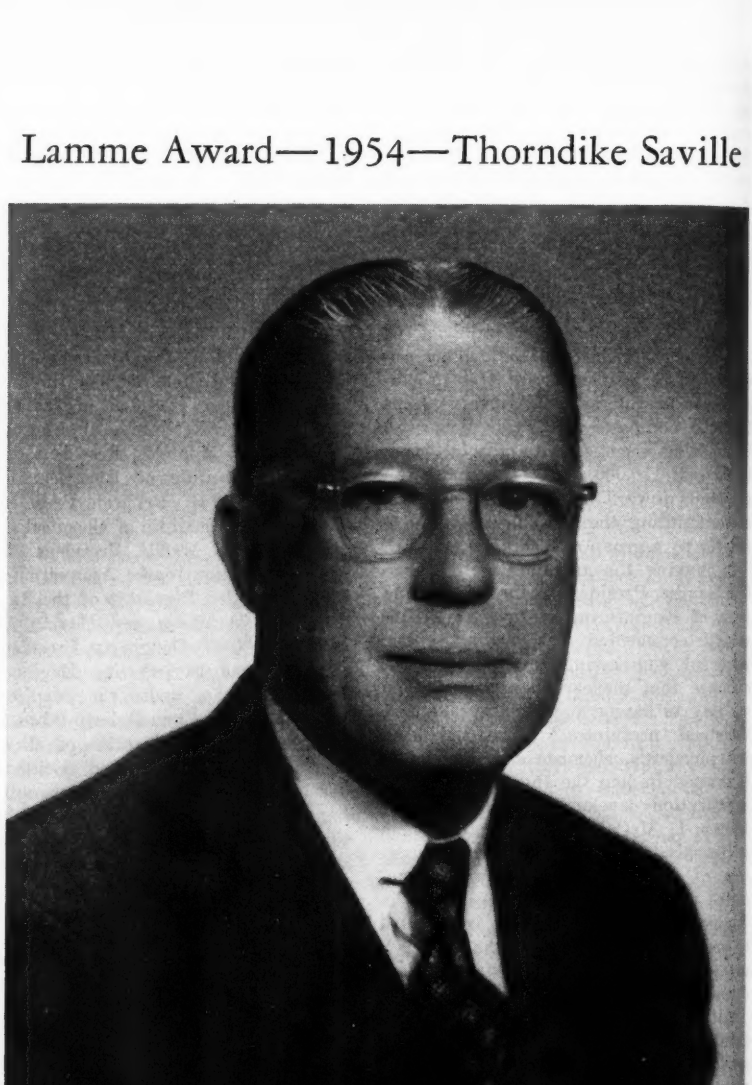
The announcement was as follows:

"The pressing problems of nuclear engineering and the related sciences are to be dealt with authoritatively by a group of leading engineers. In this announcement, Thorndike Saville, President of Engineers Joint Council, is joined by Daniel V. Terrell, President of the American Society of Civil Enginers; Leo F. Reinartz, President of the American Society of Mining and Metallurgical Engineers; Lewis K. Sillcox, President of The American Society of Mechanical Engineers; Alexander C. Monteith, President of the American Institute of Electrical Engineers; Chalmer G. Kirkbride, President of the American Institute of Chemical Engineers; Dale L. Maffitt, President of the American Water Works Association; W. E. Blewett, Jr., President of the Society of Naval Architects and Marine Engineers, and N. W. Dougherty, President of the American Society for Engineering Education, who, under the auspices of Engineers Joint Council, have taken steps to organize the cooperation of all engineering groups and related scientists to develop discussions of nuclear engineering subjects and to deal with the publication of worthwhile papers and addresses."

The total membership of the federated societies known as Engineers Joint Council is about 170,000. The membership includes several thousand skilled engineers who are working on the critical problems of mining, processing and the use of all the materials involved in the production of energy by fission. Action by this powerful engineering group is further evidence that nuclear energy is well on the way to having important peace time industrial usefulness. As to the likelihood of an invitation to others to join the engineers' program, Dean McCabe said:

"We agree as to the desirability of bringing in the physicists, chemists and perhaps other related groups, but at the moment our responsibility is largely in the engineering field."

Lamme Award—1954—Thorndike Saville



To THORNDIKE SAVILLE *for his distinctive leadership in organizations for the advancement of the engineering profession and of engineering education, for his valued service to the American Society for Engineering Education in numerous capacities including its Presidency in 1949-50, for his distinguished contributions to*

engineering education as an educator and administrator, for his untiring service to ECPD as Chairman of its Committee on Accreditation, for his leadership in the Engineers' Joint Council during its reorganization and as its President in 1954, for his engineering contributions and wise counsel to governments in the fields of water supply, beach erosion, sanitary engineering and water power, we award this twenty-seventh Lamme Award.

THORNDIKE SAVILLE was born in Malden, Massachusetts on October 3, 1892, the son of Caleb Mills Saville, who was a Division Engineer under General Goethals on the Panama Canal, and later became chief engineer of the Metropolitan Water Bureau of Hartford, Conn., and Elizabeth Thorndike Saville. His secondary school education was received in the schools of Malden and Brookline, Mass., and on the Panama Canal. He received the bachelor of arts degree from Harvard and the degree of B.S., *magna cum laude,* from Dartmouth College, both in 1914. In 1915, he was granted the C.E. degree from Dartmouth's Thayer School of Engineering. Before entering the Army in 1917, he was awarded the degree of M.S. both from Harvard and M.I.T. Clarkson College of Technology in 1944 and Syracuse University in 1951 awarded him the honorary degree of Doctor of Engineering.

As a first lieutenant during World War I, he directed design and partial construction of the Big Bethel Water Supply and Filtration Plant for Langley Field and Fort Monroe and supervised construction of the sewerage and drainage systems at Langley Field. After the war, he investigated river regulation and sewage treatment processes in England and France under a Sheldon Traveling Fellowship from Harvard.

In 1919, with his appointment by the University of North Carolina as associate professor, later professor of hydraulic and sanitary engineering, Dr. Saville began a career of engineering education achievements that were to parallel significant contributions to engineering, research, and community service. Today, he is the dean of the College of Engineering at New York University; president of the Engineers Joint Council; a member of the U. S. Beach Erosion Board; chairman of the Committee on Education, ECPD; engineer member of the New York State Public Health Council; and consultant to the Long Island State Park Commission.

As engineer and citizen, Dean Saville has devoted a lifetime to the conservation and judicious use of the nation's natural resources, particularly its water reserves. His early work in the statistical analysis of river flow proved valuable in flood control and river and stream pollution projects. In 1931, he wrote a comprehensive description of the power situation in the South, describing the growth and future possibilities of hydro-electric developments in southern states and which the American Academy of Political and Social Science published. For the National Resources Board in 1935, Dean Saville made an inventory of the nation's water resources. In 1926 the Rockefeller Foundation sent him as a consultant to the government of Venezuela to investigate the water supply for Caracas.

He has originated, carried out or directed studies in stream gauging, beach erosion, underground waters, rainfall, floods, evaporation, and silting. A few of the subjects covered in his many publications include the administrative control of water pollution; methods of estimating flood flows; national planning for coastal protection; and the nature of color in water.

In 1932, New York University appointed him professor of hydraulic and sanitary engineering, three years later named him associate dean, and in 1936, dean of the College of Engineering. At New York University his policies have extended the range of undergraduate instruction and encouraged academic and sponsored research that enlarges the opportunities for advanced engineering education while at the same time adding to

the store of scientific knowledge. His academic programs have particularly raised to major status the fields of sanitary science, meteorology and oceanography, and engineering physics.

Dean Saville was early in recognizing the possibilities of cooperation between institutions of engineering education and the municipality and other publics, including regional industry. He was instrumental in the joint construction, with the city of New York, of the Lewis Van Carpenter Sanitary Engineering Research Laboratory at New York University.

Appreciating the interdependence of the arts and sciences in the modern world, Dean Saville has also promoted several cooperative programs with liberal arts colleges.

His abiding interest in the student begins at orientation programs, before the freshman walks into his first class—and continues long after the granting of a degree, as thousands of alumni will testify. He is known to devote the same penetrating thought and incisive expression to a message in a student publication as to an address to colleagues.

Dean Saville's efforts toward improving the status and quality of the engineer and his profession is reflected in a record of long and untiring service in numerous activities of the A.S.E.E., the Engineers Council for Professional Development and the A.S.C.E. He was president of the A.S.E.E. in 1949–50, president of the Metropolitan Section of A.S.C.E. in 1937–43, and a director of the Society from 1945 to 1948. Engineering education owes an enduring debt to his pioneering labors in the establishment of basic and authoritative accrediting policies and procedures. In 1953, Dean Saville represented the engineering societies of the United States at the Conference on Engineering Education in London conducted by the Engineering Societies of Western Europe and the U. S.

Among his other associations have been Chief Engineer of the North Carolina Geological Survey; consultant to the U. S. Geological Survey and the Mississippi Valley Committee investigation of flood frequencies; member, Governor's Technical Advisory Committee, New York State Department of Commerce; member, National Advisory Committee, Engineering Science and Management War Training; advisor to the Public Works Committee of the first Hoover Commission; consultant to the National Science Foundation; chairman, Engineering Panel on Water Supply for New York City; member of the National Advisory Health Council, U. S. Public Health Service.

Dean Saville's career is fulfillment in a larger sense of the philosophy of an engineer as he expressed it recently in writing to students: "The elements of true creation, imaginative and sage design, public responsibility, and ethical practice are inherent in the individual, waiting to be activated by precept of the instructor and by intellectual and spiritual growth based upon, but not automatically resulting from a broad and sound education."

In the News

A total of 176 research projects supported by funds amounting to $400,516 are now under way in the various laboratories of the **University of Wisconsin College of Engineering**, the 1953–54 report of the Engineering Experiment Station, published today, reveals. The research projects, all highly technical, cover a wide variety of engineering problems ranging from "Condensation of Vapor as Ice" in chemical engineering to "Methods for Improving the Ductility of Concrete" in the mechanics department.

George Westinghouse Award—1954—
Thomas James Higgins

To THOMAS JAMES HIGGINS *for his tireless efforts in the interests of better teaching; for his capacity to stimulate others in the classroom, in committee meetings, and in meetings of professional groups; for his many published papers, critical reviews, and offerings in technical conferences; for his effective contributions*

to undergraduate education, to graduate education, to research; for his genuine thoughtfulness of others; and for his unswerving devotion to the teaching profession, we award this ninth George Westinghouse Award.

THOMAS JAMES HIGGINS was born in Charlottesville, Virginia, on July 4, 1911. He attended Cornell University, receiving the degree of Electrical Engineering (E.E.) in 1932, and in June of 1937 the M.A. degree in Mathematics. From Purdue University he received the Ph.D. in Electrical Engineering in 1941. During his four years at Purdue he was an Instructor in Electrical Engineering while diligently pursuing the Ph.D.

His other teaching experience includes one year at Auburn Intercollegiate Center (1933–34), two years at Wyomissing Polytechnic Institute (1935–37), one year at Tulane University (1941–42), and six years at the Illinois Institute of Technology (1942–48).

His industrial employment includes short periods with Ebasco Services, Inc., Agfa-Ansco Corp., City of Ithaca, Associated Gas and Electric Corp., Wenderly Construction Co., and Fuller Construction Co. He is a registered engineer in Illinois and Wisconsin, and does consulting engineering in the fields of heavy-current bus bar distribution system design, and in automatic control theory analysis.

It was in his junior year in college that he decided to make teaching his vocation. He has never swerved from this decision nor consciously neglected any means of preparing himself to this end. Those of us who know him well fully appreciate the sincerity of this early decision and the complete devotion and zeal with which Dr. Higgins pursues his objective.

During his teaching career, he has taught courses covering practically all of the material which one finds in the modern undergraduate curriculum in Electrical Engineering. Since coming to Wisconsin in 1948, he has outlined and taught five new graduate courses in electrical engineering. These courses embrace thorough coverage of material in the theory of nonlinear electric circuit analysis, matrix and tensor theory of electric networks and machines, modern operational methods of electric circuit analysis, and both basic and advanced servomechanism and automatic feedback control theory.

As to research and publications, Dr. Higgins has indeed attained distinction. His published works to date are approximately ninety in number. They cover a broad range of interests, including a particular emphasis on the analytic solution of a variety of problems in electrical engineering. As one interested generally in biography and history, and especially as they relate to science and engineering, he has published several exhaustive bibliographies listing the available booklength biographies of men of science and technology in a number of different fields, as well as a recent detailed bibliography of books and papers devoted to the history and development of electrical engineering and electrophysics. He has contributed to several abstracting journals and has edited a number of books for different publishing houses.

He was married to Louise Logan of Indianapolis on April 5, 1942. Mrs. Higgins, a graduate of Earlham College, possesses a combination of sparkling humor, easy nature, and ready understanding which contributes much to their home and social life. They have two children, Janet and James, eight and four years of age, respectively.

Dr. Higgins' honorary and professional association include Eta Kappa Nu, Sigma Xi, AIEE, ASEE, NSPE, AAUP, Mathematical Association of America, and the Wisconsin Society of Professional Engineers. His committee activities and responsibilities in these organizations are many, and thus to most of these he has contributed much time and effort.

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Laying the Foundation for Engineering Graphics

By J. G. McGUIRE

Professor of Engineering Drawing, The Agricultural and Mechanical College of Texas

As we lay out our programs in drawing for the beginning engineering college student, the question arises: "Where shall we start and how shall we proceed in directing the efforts of the young engineering student as he builds a working background in graphical procedures?" In particular, this question arises when the time allowed is very limited for developing in the student the ability to use graphics as effectively as he is taught to use mathematics. Also, the question arises when we see many students come to engineering college with some background in drawing while others have had no experience with drawing nor any knowledge of the instruments and equipment associated therewith.

Is it possible or desirable to start all beginning college students at a level low enough for those with no experience and spend a semester building a background in lettering and simple views? For those students who have gained this experience in high school, such a program can be quite exasperating. Also, for the student with average or above ability but with no previous drawing experience, a program that does not advance fast enough into college grade material can waste a lot of valuable time.

Integrated Program

It would seem possible to build an integrated program which advances into the elements of descriptive geometry during the first semester that will serve all entering students who have average or above ability regardless of their previous experience in drawing. Under such a program the student can be familiarized during the first semester with most of the principles of drawing that are commonly reserved for descriptive geometry, with at least a part of the second semester devoted to applications designed to suggest to the student how graphics may be used as an analytical tool on a footing equal to that of mathematics.

A program that would provide for such progress during the student's first year in college drawing would demand that the principles of descriptive geometry be carefully integrated with the material in the basic drawing course. In this way it would appear that much du-

plication could be eliminated. As an example, possibly equal results could be obtained by the elimination of much of the drill on completion type problems of obtaining the third view of complicated mutilated blocks and placing emphasis on *realtionship of views, lines of sight,* and *reference planes* while teaching some of the basic principles of descriptive geometry. Not only would there be considerable elimination of duplication of effort on many items but the student would come to think of the principles of descriptive geometry as more closely related to those of basic drawing and he would be less reluctant to call upon these principles in the solution of problems that may lend themselves to graphical solutions.

Of course such a program would demand that some of the weaker students be given a more elementary and possible non-credit course in preparation for the integrated course. But the division should not just be a separation of those students who have, from those who have not, had high school drawing. It seems likely that the majority of students who have had no drawing would be quite successful in the integrated program and gain a background in graphical procedures more nearly comparable to their training in mathematics at the end of their freshman year.

Meeting Notices

ECPD Annual Meeting—Cincinnati, Ohio, October 28–29, 1954, Alms Hotel.

Subject: The First Five Years of Professional Development.

ASEE General Council—Cincinnati, Ohio, 6:00 P.M., October 27, 1954, Alms Hotel.

ASEE Technical Institute Division—Committee of Twenty One and Chairmen of Committees, Cincinnati, Ohio, October 27, 1954.

Report of the Secretary, 1953-54

It is a pleasure to present in this annual report an outline of several new projects which have been undertaken by the ASEE during the current year. These penetrate deeply into many of the principal problems of engineering education and show promise of making substantial long-range contributions to the work of the Society.

The project Evaluation of Engineering Education, which is entering its second year, has aroused widespread participation among faculty members in engineering colleges throughout the country. It has served to turn the attention of engineering educators ahead to an evaluation of the future needs of the profession, with due consideration to the rapid changes taking place in a number of fundamental areas of science and technology.

A significant project, initiated this year, is the Humanistic-Social Research Project. This will focus attention upon the development of quality educational programs in the Social Sciences and Humanities. The Summer Institute program, also launched for the first time this year, is off to a good start. It includes two conferences dealing with Solid State Physics in Engineering Education and Nuclear Science in Engineering Education. Plans are being made for Summer Institute Conferences of a similar character for next year. This year, the Society is sponsoring six Summer Schools, the largest number in its history. Another project, currently in the formulative stage, is a comprehensive evaluation of the curricular goals and objectives of graduate study. This project has considerable significance, in view of the substantial growth of graduate programs and the rising graduate enrollments.

Various Committees and Divisions of the Society are currently devoting a great deal of attention to exploring the newer developments in science and technology and in trying to interpret these in terms of their influence upon engineering education in the years ahead. Experience has repeatedly shown that newly developing areas illuminate the more traditional fields and concepts with new ideas and new fundamental analytical approaches. This type of evolution has brought about much of the progress in engineering education. It is in this area of operation that the Society can serve its highest function by providing a national forum to bring together divergent viewpoints and subject them to critical analysis.

A considerable amount of attention is currently being devoted to two other aspects of engineering education. One of these is the possibility of developing closer integration of course material. The objective here is to help the student to see similarities in the analytical methods of approach in many diverse fields. This would give him a broader perspective and a deeper appreciation of the underlying unity of the physical sciences. The second area of general interest is that dealing with means of developing the student's latent powers of resourcefulness and creative ingenuity. Engineering is basically a creative profession and it seems imperative that engineering education should produce individuals who have a creative outlook in life. Unfortunately, there are no simple solutions to these problems. To achieve results in these areas requires critical analysis of objectives to be sought and soundly conceived experimentation.

Evaluation of Engineering Education

The ASEE Committee on Evaluation of Engineering Education presented at

the Annual Meeting its Interim Report, representing a thorough reappraisal of engineering education in the light of the needs of the profession in the years ahead. This report is based upon recommendations of over 118 institutional committees. It is expected that this Interim Report will be allowed to stand for approximately a year and will then be revised in the light of further recommendations of the institutional committees. In the meantime, the institutional committees will be asked to prepare their own analyses. Bound copies of these reports will be placed in engineering libraries throughout the country, as representing the current thinking on trends in engineering education.

A meeting of a number of leading industrialists brought forth many exceedingly helpful viewpoints which have clarified industry's views on the trends of engineering and engineering education in the future.

Copies of the Interim report can be obtained by writing to the Secretary of ASEE. The price is 20¢ each or 12¢ each in quantities of 100 or more.

Humanistic-Social Research Project

Ten years ago, the Report on Investigation of Engineering Education After the War set forth an urgent recommendation that steps be taken to improve that portion of the engineering curriculum dealing with the humanities and social sciences. A great deal of a general nature has been written about this need and many platitudes have been voiced. However, only a few schools have undertaken a comprehensive analysis of this area of education with a view toward developing a well-integrated program of courses. For the most part, engineering colleges have appropriated existing courses in the liberal arts schools.

It now seems timely to conduct a serious and penetrating analysis of this important area of instruction. This will be the objective of the Humanistic-Social Research Project, initiated this year under a grant of $30,000 from the Carnegie Corporation. The project will be directed by Dr. George A. Gullette, North Carolina State College. The Chairman of the Committee will be Dr. E. S. Burdell, President of The Cooper Union.

This project will seek out and analyze those ideas, courses, programs, and procedures which appear to be well-conceived and which show fresh and imaginative approaches. The project will not only analyze existing programs, but it will also project ahead and develop its own recommendations for course material and curricular improvement. This will be a two year study. Preliminary studies are now under way.

Summer Institute Program

A new innovation this year is the Summer Institute Program. Its purpose is to organize conferences in critical areas of engineering education where there appears to be a possibility of making substantial improvements. Some of these areas deal with rapidly developing fields of scientific and technological knowledge which appear to be very fundamental and which have a substantial bearing upon engineering of the future. Others may deal with the unification of subject matter which cuts across curricular boundaries.

This year, two Summer Institutes have been planned. One will be in Solid State Physics in Engineering Education, to be held at Carnegie Institute of Technology, June 21–25, 1954. The other in Nuclear Science in Engineering Education will be held at Northwestern University, September 7–10, 1954. Both of these Summer Institutes will attempt to get a clarification and logical organization of fundamental concepts. They will assess the material as to its importance in engineering education and seek logical and orderly patterns for teaching purposes. It is hoped thereby to reduce substantially the amount of time lapse in translating new fundamental concepts into engineering education and engineering practice.

The two Summer Institutes this year

were financed by grants totaling $15,500, from the National Science Foundation. Each Summer Institute was preceded by a closed conference in which leading authorities in research and education gathered to discuss the material. The closed conference for the Solid State Physics was held at the University of Illinois. The closed conference on Nuclear Physics in Engineering Education was held at Columbia University.

Summer Schools

This year the Society is sponsoring six Summer Schools, the largest number in its history. These Summer Schools are as follows:

Engineering Economy Committee—Evaluation of Analytical Techniques of Engineering Economy
Electrical Engineering—Elements of Design of Digital Control Circuits
Humanistic-Social—Workshop for Humanistic-Social Research Project
Engineering Mechanics—Evaluation of Graduate Training in Mechanics
Mechanical Engineering—Teaching of Machine Design and Manufacturing Processes
Educational Methods and General Electric Company—Teaching Methods Seminar

In addition to these, the Instrument Society of America will hold a one-day meeting jointly with ASEE at the Annual Meeting in Urbana.

Young Engineering Teachers' Activities

The YET movement in the Society has gained great momentum as a consequence of steps taken by Divisions and Sections of the Society to bring young teachers into active participation. This year the YET Committee has been responsible for the membership campaign. This has resulted in approximately 400 new members in the instructor and assistant professor ranks.

The YET movement holds great promise both for the future of the Society and also in providing opportunities for the professional growth of young engineering teachers. Many engineering colleges now have YET organizations. They provide a pleasant social experience and a means of enabling young faculty members to take hold of the principal problems facing engineering education and broaden their outlook and perspective. Many of the Sections of the Society now have half-day meetings organized entirely by the YET's.

Again this year the Society is sponsoring a paper contest for young engineering teachers. The awards will be given at the Annual Banquet. Last year there were 75 entries in the YET Contest.

The Fall Meeting of ASEE–ECPD

The Fall Meeting of ASEE–ECPD was held at the Statler Hotel in New York in October. The ASEE portion of this program, arranged by ECRC and ECAC, featured a conference on Creative Thinking, with speakers who themselves are eminently creative in the fields of music, art, writing and scientific and engineering research. This conference created a great deal of interest in a field which merits further investigation.

Another portion of the program dealt with the problems and policies of accreditation of engineering curricula. Approximately 400 educators and professional engineers attended this meeting.

ECRC Activities

The ECRC this year published its Review of Current Research, listing principal research activities in progress in engineering colleges throughout the country. ECRC also has been working on a policy statement regarding research in engineering colleges.

ECAC Activities

The ECAC Manpower Committee is actively studying the supply and demand of engineering manpower and the problems as they relate to military demands on engineering manpower. Other ac-

tivities of ECAC will be summarized in the Committee's Annual Report.

The Military Affairs Committee of ECAC has been actively studying a number of phases of the ROTC problem, including the implications of the reduction of Air Force ROTC quotas.

The Selection and Guidance Committee of ECAC is currently working with the Educational Testing Service in devising tests as selective instruments for employers. A pilot run will be made in a few colleges. They are also endeavoring to construct a placement test which will indicate to senior students their own interests and aptitudes.

The Committee on Secondary Schools of ECAC is currently working with other professional and educational societies in an attempt to find a means of improving high school preparation of engineering students. This is a difficult problem, since it is complicated by the shift in high schools toward general education and also by the exodus of good science and mathematics teachers from schools into industry.

Graduate Study Proposal

The Society is currently considering a new project to investigate the objectives and curricular organization of graduate study. There has been very substantial growth in graduate work in all curricular areas over the past ten years and there is every indication that this growth will continue in the years ahead. The Society has never made a thorough study of curricular goals at the graduate levels of instruction.

Associate Institutional Memberships

This year, the Associate Institutional Membership Drive, under the able Chairmanship of Mr. Jesse McKeon, added its one-hundredth Associate member to the Society rolls. These Associate Institutional Members are companies, all of which have substantial engineering operations. This program of cooperation between engineering education and industry, which started with the formation of the ASEE Division of Relations with Industry, has proven of great benefit both to industry and to the colleges.

Dues Amendment

The amendment to By-Law IV, which was submitted to the Society in April, 1954, passed by a 76% vote. This provides for a nominal increase in dues next year, the dues being $8.00 for members over 36 years of age and $6.00 for those under. This will make it possible to operate the Society with a small margin of revenue.

Division Publications

The Society membership owes a deep debt of gratitude to the individuals in the Divisions who were responsible for the publication of the various technical journals published by the Divisions. These publications serve a vital role in bringing to the engineering teachers helpful information on methods of improving their teaching. They are all operating on a self-financing basis and even the advertising is solicited by the Division officers. There is little glory but great returns in doing this kind of a job.

The Technical Institute Division came through with two very helpful publications, "The Engineering Technician" and "Literature Significant to Education of the Technical Institute Type." These will prove extremely useful both to the teachers in this field and the students who are contemplating technical institute level education.

The Relations with Industry Division held a highly successful conference in Detroit on the subject "The First Five Years After Graduation." This is a problem of professional development of young engineers in industry, aimed at expanding educational opportunities and means of professional growth of the young engineer.

Cooperation with Other Organizations

During the past year, the ASEE continued its active participation with Engineers' Joint Council, Engineers' Council

for Professional Development, American Standards Association and many other organizations. The President of EJC this year is Dean Thorndike Saville, our ASEE representative to EJC. The ASEE will have three representatives attending the UPADI meeting of engineers of the western hemisphere in Sao Paulo, Brazil, this August. President Grinter and Dean Saville will both attend the EUSEC meeting on engineering education in Switzerland in the Fall of the year as representatives of ECPD. The travel expenses for their representation have been provided without drawing upon Society funds.

Respectfully submitted,

ARTHUR BRONWELL, *Secretary*

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

ENGINEER WANTED—ORGANIZATION planning establish research fellowship for study of land use, conservation and rehabilitation wishes contact graduate civil engineer age 25 to 35, preferably some experience gravel economics and operation with imagination and interest in landscape engineering. Objective eventual specialized consulting association. Location eastern states. **Reply box S1.**

ASSISTANT PROFESSORS (2) OF Electrical Engineering. University of North Dakota, Grand Forks, No. Dak. Duties: One man to teach electronic and communication courses, and one man to teach electrical power courses to undergraduate students. Appointments to begin in September 1954. An advanced degree plus some teaching or industrial experience preferred. Submit resume of education and experience to Head, Electrical Engineering Department.

IN MEMORIAM

KARL TAYLOR COMPTON

1887–1954

Dr. Karl Taylor Compton, President of the American Society for Engineering Education in 1938–39 and its Lamme Medalist in 1949, and President of the Massachusetts Institute of Technology from 1930 to 1949, died in New York on June 22, 1954.

As Chairman of the Corporation, the post he held at M.I.T. since 1948, Dr. Compton had participated in his customary gracious manner in the Institute's 88th commencement exercises on June 11 and in the alumni reunions of the following weekend. In New York on June 16, he was stricken with a heart attack and died five days later. A memorial service at M.I.T. on June 25 was attended by hundreds of alumni, leaders in science and education, and representatives of governments and learned societies.

As M.I.T.'s ninth President, he was responsible for a broadening and enrichment of the curriculum, adding new courses and rearranging others as he anticipated the needs of industry and society in a changing world. With the Division of Humanities at M.I.T., Dr. Compton introduced to the Institute a new concept of the values of science and engineering in the advancement of civilization. He sought to balance a precise training in the professions by adding studies of their wide social implications, so that students of science, engineering, and architecture might also learn to participate intelligently in social and economic affairs.

In 1937, during this period of developing educational philosophy, Dr. Compton was elected Vice-President of the Society for the Promotion of Engineering Education and one year later became its President. Earlier, he had served as a member of its Committee on Graduate Studies (1931 to 1933) and as a member of the Council (1933 to 1936); later he continued service on the Council from 1939 to 1946. Dr. Compton was Chairman of the Society's Committee on Engineering Manpower in 1946.

In later years Dr. Compton's generous contribution of time to public activities led him away from M.I.T.—and eventually to give up its Presidency several years before the nominal retirement age. This record as a public servant is too extensive to be detailed here. During World War II, as a member of the National Defense Research Committee, he joined a group of brilliant men in directing a military research program of unparalleled scope and achievement. Indeed, as Dr. Killian pointed out in the memorial broadcast, so great was Dr. Compton's contribution that his citation for the Medal of Merit included the "extraordinary statement that he personally was responsible for shortening the duration of the War."

Dr. Compton was born in Wooster, Ohio, on September 14, 1887, and received the Ph.B. in 1908 and M.S. in 1909 from the College of Wooster. He served for one year as instructor in chemistry before entering the Graduate School at Princeton, where he was awarded in 1912 the Ph.D. degree summa cum lauda. In 1915, after three years as physics instructor at Reed College, Dr. Compton was recalled to an assistant professorship at Princeton, where he remained as Professor and later as Chairman of the Department of Physics until 1930.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April, 1955	W. D. Garman, Bucknell University
Illinois-Indiana	University of Notre Dame	May 21, 1955	G. E. Ellithorn, University of Notre Dame
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	G. W. Bradshaw, University of Kansas
Michigan	Michigan State College	May 17, 1955	C. C. Sigerfoos, Michigan State College
Middle Atlantic	Polytechnic Institute	Dec. 4, 1954	H. N. Jenkins, Swarthmore College
Missouri-Arkansas	University of Missouri	April 2, 1955	M. M. Jones, University of Missouri
National Capital Area	Catholic University	Oct. 5, 1954	J. C. Michalowicz, Catholic University
New England	Massachusetts Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	A. F. Inst. Wright Field	Sept. 17–18, 1954	K. F. Sibila, University of Akron
	University of Akron	May 7, 1955	
*Pacific Northwest	Oregon State College	Spring, 1955	M. L. Jackson, University of Idaho
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1954	B. M. Green, Stanford University
*Rocky Mountain	University of Utah	Fall, 1954	D. F. Peterson, Colorado A. and M. College
Southeast	University of Tennessee	April 14–16, 1955	H. V. Flinsch, Mississippi State College
Southwest	University of Oklahoma	April 8–9 1955	V. L. Doughtie, University of Texas
Upper New York	Cornell University	Oct. 22–23, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

ADAMS, RICHARD CALVIN, Instructor in Mechanical Engineering, Pennsylvania State College, State College, Pa. H. L. Dillenbeck, M. S. Gjesdahl.

ALEXANDER, CLAUDE H., Coordinator of Technical Service, B. F. Goodrich Chemical Co., 324 Rose Building, Cleveland 15, Ohio. L. M. Freeman, A. Syverson.

ANDERSON, QUENTIN L., Training Coordinator, Fisher Body Cent. Eng. Activities, Detroit, Michigan. E. C. Flarity, S. J. Hirschfield.

ANTHONY, RICHARD LEWIS, Chief Mechanical Engineer, Westcott & Mapes, Inc., New Haven, Conn. W. J. Wohlenberg, G. Robley.

BATTEAU, DWIGHT WAYNE, Assistant Professor of Engineering, Harvard University, Cambridge, Mass. C. H. Berry, C. L. Daives.

BAUGHMAN, GEORGE H., JR., Instructor of Engineering, Drexel Institute of Technology, Phoenixville, Pa. C. A. Kapp, S. B. Collins.

BEERS, YARDLEY, Associate Professor of Physics, New York University, New York, New York. H. Torgerson, D. B. Porter.

BERRY, DONALD S., Professor of Engineering, University of California, Berkeley, California. H. E. Davis, R. A. Moyer.

BETTER, BERNARD RAYMOND, Director of Research, Scully-Jones and Co., Chicago, Ill. L. E. Doyle, K. J. Trigger.

BLACK, HAROLD LISLE, Professor of Engineering Research, Pennsylvania State University, State College, Pa. C. H. Tindal, Arthur T. Thompson.

BLACKBURN, JACK BAILEY, Research Engineer, Purdue University, Lafayette, Indiana. C. Lovell, Jr., M. B. Scott.

BOND, THOMAS HOBART, Assistant Professor of Engineering, State University Maritime College, Glen Cove, New York. J. J. Foody, A. O. Porter.

BOODLEY, NANCY KESTER, Instructor of Engineering Drawing, Pennsylvania State University, State College, Pa. H. L. Dillenbeck, M. S. Gjesdahl.

BOUDREAUX, FELIX JOSEPH, Associate Professor of Electrical Engineering, Southwestern Louisiana Institute, Lafayette, Louisiana. H. R. Mason, R. E. Jenkins.

BRASUNAS, ANTON DESALES, Assistant Professor of Chemical Engineering, University of Tennessee, Knoxville, Tennessee. H. J. Garber, N. W. Dougherty.

BURNETT, JAMES ROBERT, Associate Professor of Electrical Engineering, Purdue University, W. Lafayette, Indiana. R. P. Siskurd, W. M. Hesselberth.

BURRILL, CLAUDE W., Assistant Professor of Mathematics, New York University, New York, N. Y. H. A. Giddings, G. A. Yanosik.

CASE, PAUL W., Associate Professor of Manufacturing Processes, Purdue University, Lafayette, Ind. H. A. Bolz, R. W. Lindley.

CHAVE, CHARLES T., Asst. Chief Engineer, Stone & Webster Engineering Corp., Boston, Mass. W. F. Ryan, D. H. Feener.

CHRISTENSEN, HARVEY D., Assistant Professor of Mechanical Engineering, Oregon State College, Corvallis, Ore. J. L. Gray, E. C. Willey.

CIPRIANO, WILLIAM, Instructor in Engineering, East Los Angeles Junior College, Los Angeles, Calif. L. W. Holman, C. E. Guse.

CLARK, JOHN R., Associate Profesor of Electrical Engineering, Purdue University, Lafayette, Ind. L. E. Beck, L. A. Kramer.

CLYDE, ARTHUR W., Professor of Agricultural Engineering, Pennsylvania State University, State College, Pa. E. A. Myers, J. H. Moore.

COLBY, MALCOLM Y., Professor and Chairman, Department of Physics, University of Texas, Austin, Tex. W. R. Woolrich, B. E. Short.

COVINGTON, BEVERLY J., Instructor in Civil Engineering, Northwestern University, Evanston, Ill. M. B. Gamet, C. W. Muhlenbruch.

CRAIG, EDWARD J., Assistant Professor of Electrical Engineering, Northeastern Uni-

versity, Boston, Mass. M. W. Essigmann, L. F. Cleveland.

CUMMING, JOHN T., Instructor in Chemistry and Chemical Engineering, Case Institute of Technology, Cleveland, Ohio. T. J. Walsh, W. Van Voorhis.

CURRERI, JOHN R., Associate Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. J. Modrovsky, J. Bartels.

DAVIDS, NORMAN, Professor of Engineering Mechanics, Pennsylvania State University, State College, Pa. J. W. Breneman, G. J. Hasslacher.

DAVIS, JEFFERSON D., JR., Associate Professor of Civil Engineering, Tuskegee Institute, Tuskegee Institute, Ala. W. Allan, W. L. Willig.

DETWILER, VINTON V., Associate Professor of Research, Pennsylvania State University, State College, Pa. A. Addison, C. H. Tindal.

DEXTER, GREGORY M., Consulting Ind. Engineer, Scarsdale, New York. L. E. Grinter, A. B. Bronwell.

DOLANSKY, LADISLAV O., Assistant Professor of Research in Communications, Northeastern University, Boston, Mass. W. C. White, F. R. Henderson.

DOYLE, JOHN R., JR., Assistant Professor of English, The Citadel, Charleston, S. C. J. Anderson, J. C. Key.

DUNK, ALLAN C., Instructor in Mechanical Engineering, Purdue University, Lafayette, Ind. A. S. Hall, Jr., J. B. Lusk.

EASTMAN, R. MERRIAM, Associate Professor of Industrial Engineering, Georgia Institute of Technology, Atlanta, Ga. F. F. Groseclose, W. W. Cox, Jr.

ELESSER, THADDEUS M., 214 Talbot Lab., University of Illinois, Urbana, Ill. W. J. Worley, H. T. Corten.

ESTRIN, JOSEPH, Assistant, Chemical Engineering, Columbia University, New York, N. Y. C. F. Bonilla, T. B. Drew.

FENSKE, MERRELL R., Director, Petroleum Refining Laboratory, Pennsylvania State University, State College, Pa. D. Steryder, G. L. Haller.

FOLTZ, WILLIAM E., Assistant Vice President, New York Telephone Co., New York, New York. C. T. Shrage, D. S. Bridgman.

FOX, RAYMOND RICHARD, Instructor of Civil Engineering, Northwestern Technological Institute, Evanston, Ill. H. P. Hall, C. W. Muhlenbruch.

FREDERICK, MELVIN EDWARD, Patent Lawyer, Pennsylvania State University, State College, Pa. C. H. Tindal, R. A. Hussey.

GALBRAITH, EDWARD DALE, Instructor in Engineering Drawing, University of Toledo, Toledo, Ohio. G. E. Parkratz, J. T. Davey.

GILES, EDWARD STARKEY, Assistant Professor of Electrical Engineering, Clemson, College, Clemson, South Carolina. S. R. Rhodes, M. W. Jones.

GRAY, PAUL GORDON, Assistant Professor of Electrical Engineering, Michigan State College, East Lansing, Mich. R. L. Sweet, C. M. Cooper.

GUTZWILLER, MARTIN JOSEPH, Assistant Professor of Structural Engineering, Purdue University, West Lafayette, Ind. R. B. Wiley, M. B. Scott.

HANSEN, PETER GARDNER, Instructor of Mechanics, Missouri School of Mines, Rolla, Mo. R. A. Schaefer, R. A. Davidson.

HARRINGTON, HAROLD E., Head of Physics, Oklahoma Agricultural and Mechanical College, Stillwater, Okla. A. L. Betts, A. Naeter.

HAUGHTON, KENNETH ELWOOD, Instructor of Engineering Drawing, Iowa State College, Ames, Iowa. J. S. Kising, M. W. Alenfeldt.

HAWTHORNE, EDWARD I., Assistant Professor of Electrical Engineering, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. H. Sohon, J. S. Brainerd.

HELM, M. STANLEY, Professor of Electrical Engineering, University of Illinois, Urbana, Illinois. L. A. Rose, R. J. Martin.

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eral Electric Co., Schenectady, N. Y. W. S. Hill, M. M. Boring.

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POWERS, ALFRED XAVIER, Instructor in Agricultural Engineering, University of Massachusetts, Amherst, Mass. N. H. Stapleton, I. S. Pflug.

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PRICE, HAROLD A., Assistant Research Professor of Chemical Engineering, Michigan State College, East Lansing, Mich. R. L. Sweet, R. W. Ludt.

QUARLES, GILFORD G., Director, Ordnance Research Laboratory, Pennsylvania State University, State College, Pa. C. H. Tindal, A. T. Thompson.

QUEREAU, JOHN FORD, Chief Engineer, Engineering Department, Leeds and Northrup Company, Philadelphia, Pa. I. M. Stein, F. A. Gaty.

QUIGGLE, DOROTHY, Research Professor of Chemistry and Chemical Engineering, Pennsylvania State University, State College, Pa. G. L. Haller, D. S. Cryden.

REYNOLDS, KENNETH J., Wage and Salary Manager, Federal Telecommunication Laboratories, Nutley, New Jersey. J. H. Bryant, A. Wing, Jr.

RHOADS, ROBERT B., Assistant Professor of Agricultural Engineering, University of Maine, Orono, Maine. F. W. Peikert, R. C. Hill.

RIGGS, BERNARD MURREL, Instructor in Mathematics, Missouri School of Mines, Rolla, Mo. C. A. Johnson, R. H. Kerr.

RIVERS, GORDON E., Professor and Head, Engineering Shop Department, Wayne University, Detroit, Mich. Donald L. Perkins, H. M. Hess.

SANDERS, JOHN C., Staff Engineer—Personnel, Boeing Airplane Company, Seattle, Wash. V. M. Ganzer, A. A. Soderquist.

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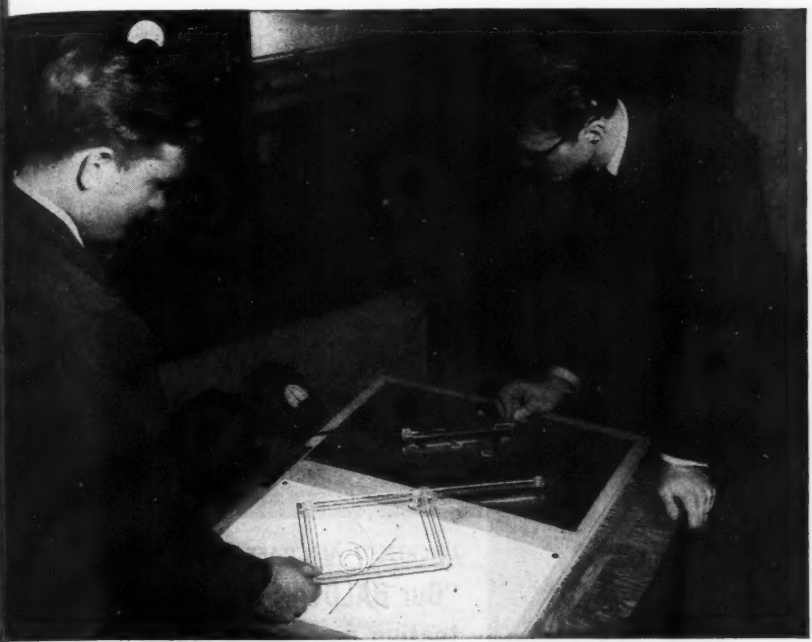

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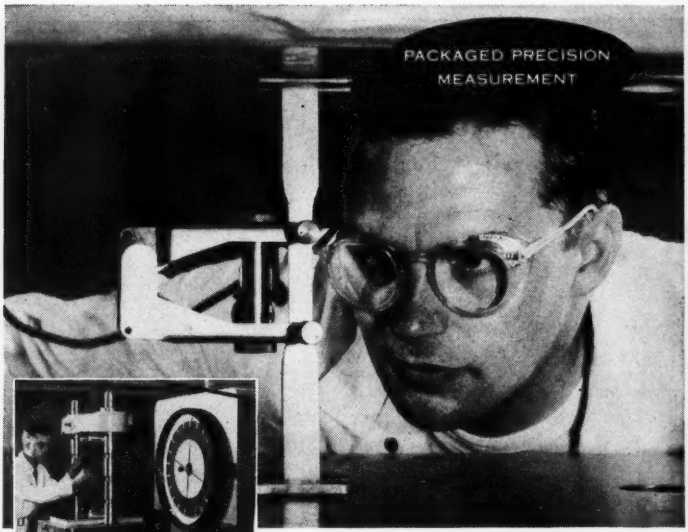

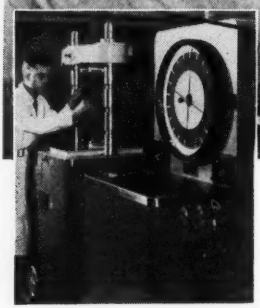

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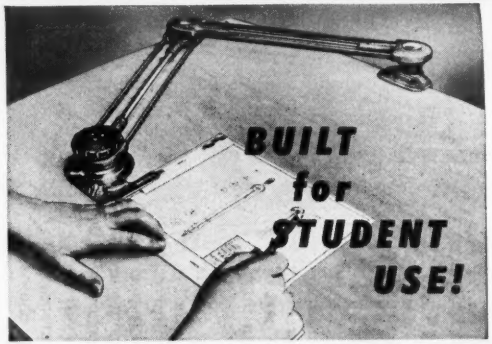

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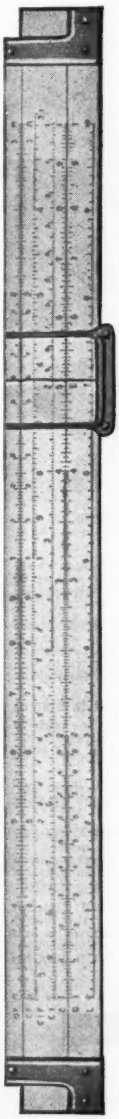

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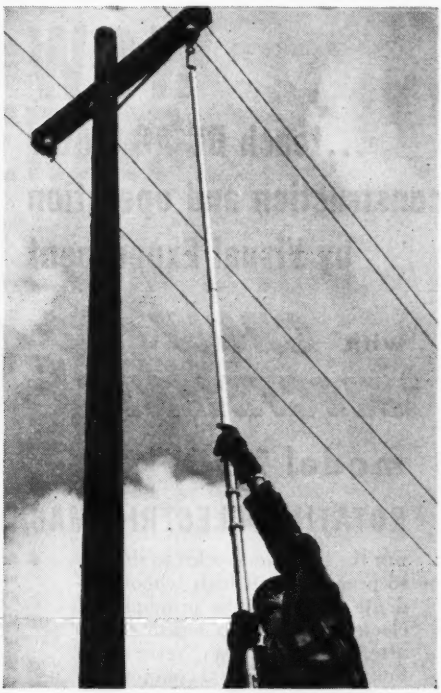

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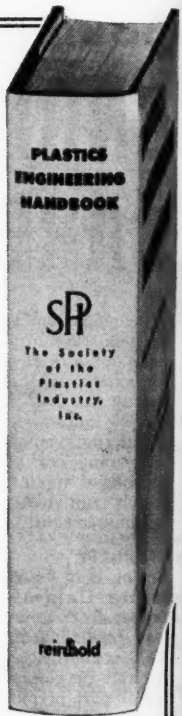

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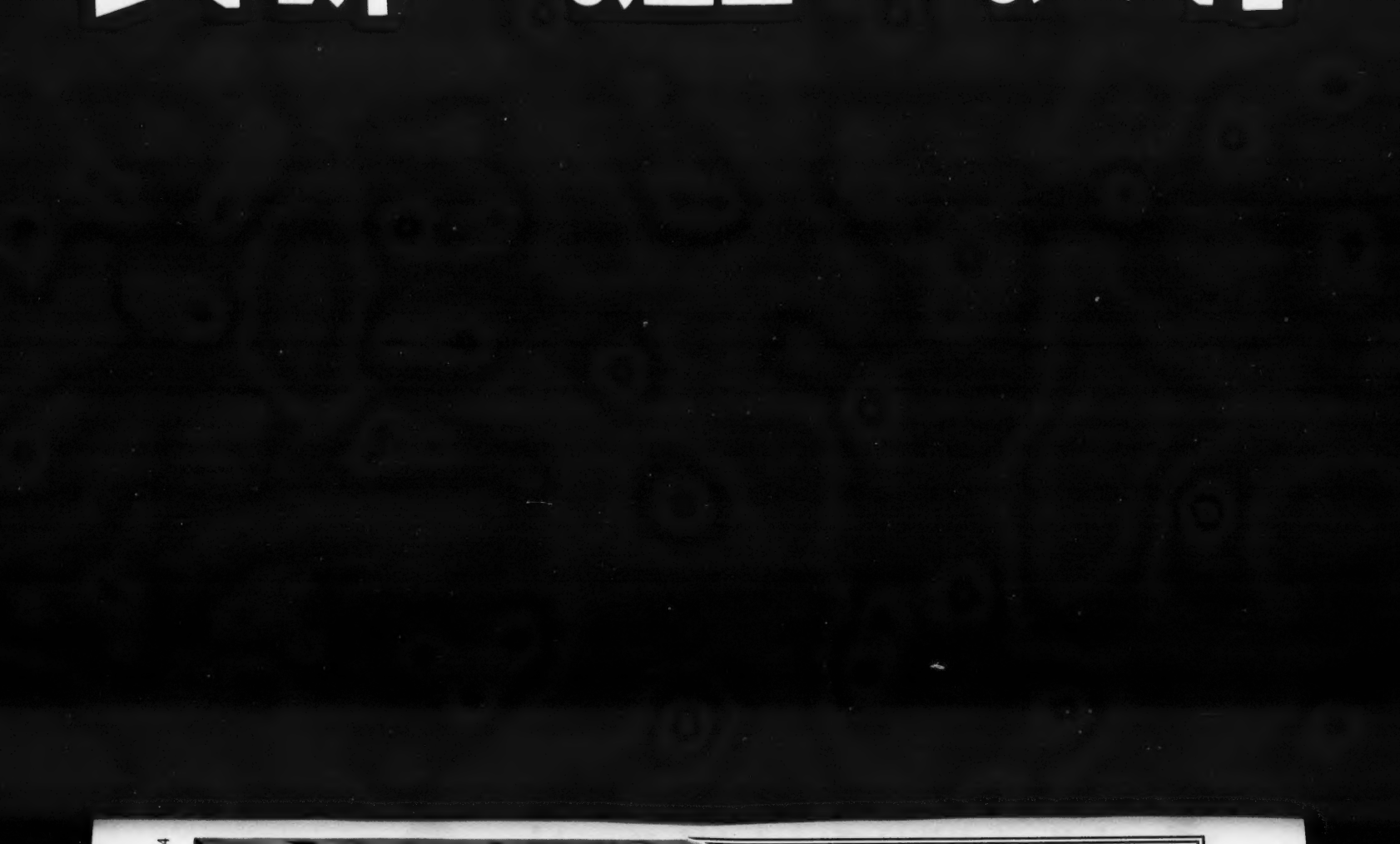

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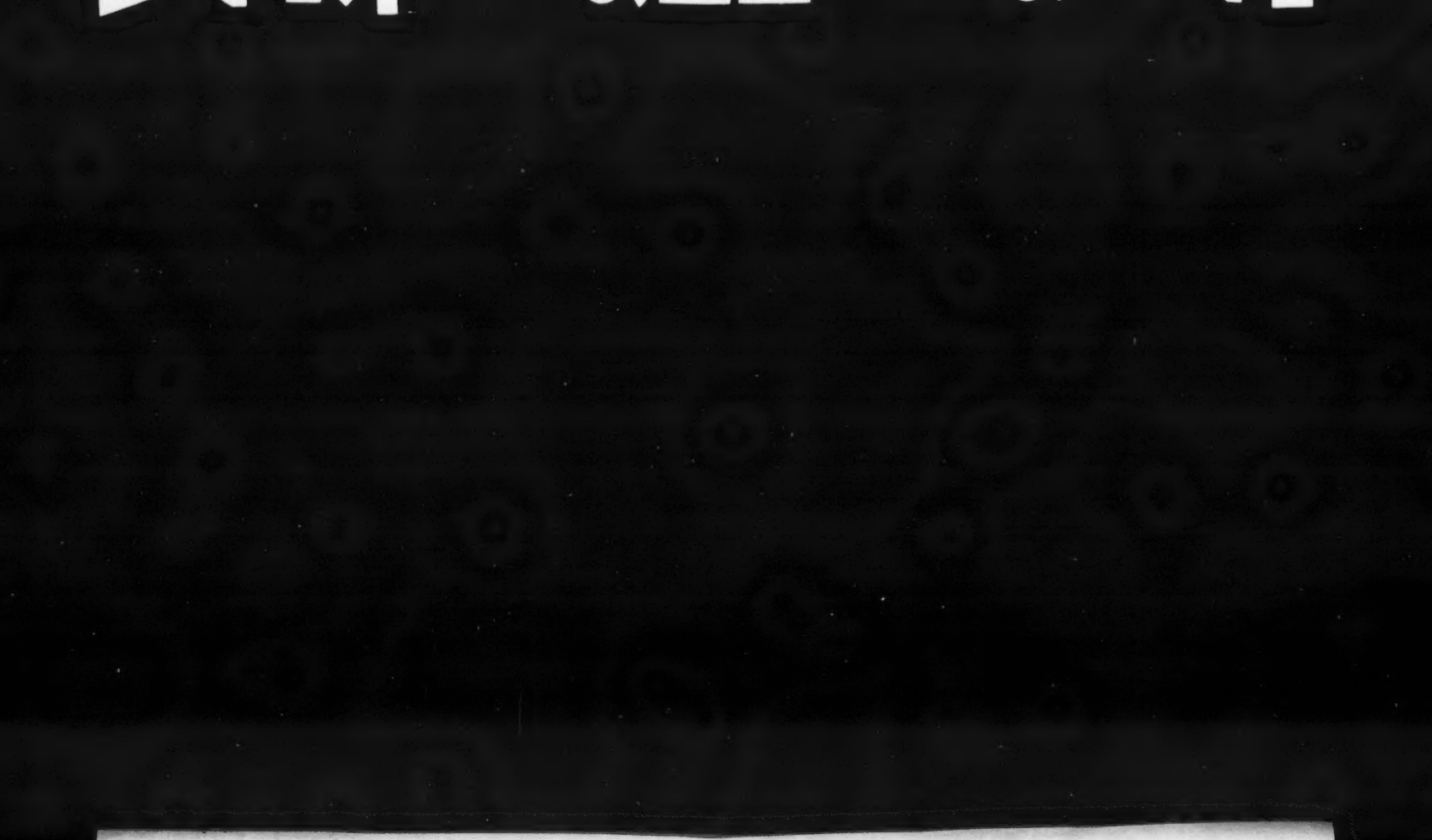
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